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Investigating the potential of mobile games as learning environments for independent adult skill development

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Abstract

The research described in this thesis is grounded in the fields of independent adult learning, user experience for mobile applications and game design. It considers the case for mobile game-based learning in the context of informal microlearning and investigates the potential of mobile games to assist the independent skills development of adults.

Initial research found that adults expressed positive attitudes towards the idea of learning with a mobile game, while even those who did not use mobile games recreationally appeared positive to using them if they perceived them as an effective way to develop their skills. Guidelines were then developed to inform the design of effective mobile learning games based on theories of adult learning, game-based engagement, mobile usability and mobile game design. These guided the development of a mobile game prototype aimed at assisting adults, speakers of English as a second language, to build their academic vocabulary.

To evaluate the effectiveness of the prototype, a mixed methods approach combining quantitative and qualitative data collection instruments was utilised. Player engagement and system usability were measured rather than direct measures of learning outcomes. Overall the results were encouraging since evaluation participants were found to be engaged by the activity and able to easily pick up the game and play. Additionally, qualitative data on participants' experiences and perceptions were collected, which supported initial research findings on the positive attitudes of adults towards using mobile games for learning. Though caution is recommended when generalising the evaluation results, the potential of mobile games for the independent learning of adults was supported.

Overall this research offers a rationale for the use of mobile game-based learning, an insight into the nature of adult learners' needs and their mobile devices usage patterns, a critical discussion on the type of learning that would be appropriate for the context, a set of guidelines for the design of mobile learning games, and finally a discussion of evaluation methods along with a collection of empirical data on the post-experiential attitudes of adults with regards to mobile games for learning.

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Thaleia Deniozou
Edinburgh, August 2015

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(Thaleia Deniozou)

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Chapter 1

Introduction

Mobile game-based learning (mGBL) is an emerging area of academic study with interesting potential for future development and possible applicability to a variety of learning frameworks. It is placed at the intersection of mobile and digital game-based learning, two relatively recent and currently growing areas of research. Mobile learning is informed by the massive growth of adoption of mobile devices into everyday life, coupled with the rapid evolution of mobile technology, leading to mobile devices being recognised as an emerging technology for learning (Johnson et al., 2011). Game-based learning on the other hand, investigates the characteristics of games that can be used to support learning (de Freitas, 2006) and is a growing academic field (Sharples et al., 2013).

It is important to note however that the mobile learning field is still relatively immature (Park, 2011) and lacking in strong theoretical underpinnings (Muyinda, 2007). It is thought to have entered the educational arena in the early 2000s, though it truly began to play a significant role with the introduction of smartphones and other powerful mobile devices (Haag, 2011) such as the iPhone released in 2007, which made smartphones widely known and accessible. Digital game-based learning on the other hand is not a new field but one that is rapidly growing, and in need of empirical evidence on the effectiveness of games as learning environments (Connolly et al., 2009). It is therefore argued that the area of mobile game-based learning (mGBL) invites research, which could lead to the development of theory as well as the collection of empirical data, but also the development of design methodologies for mobile learning games. Furthermore, perceived changes in the profiles of newer generations of learners (Prensky, 2001; Oblinger, 2004; Johnson, 2005), coupled with the acceptability of mobile technology and with digital games being aimed at every age group (Sharples et al., 2013), a growing interest in the potential of mobile games for adult learners is predicted.

1.1 Overview

The research described in this thesis examines the case of mobile games for learning and evaluates the potential of mobile game-based learning to support the independent development of skills, when used by adult learners. For the purposes of this research it was decided to narrow down the target audience of adult learners to a more specific age group, which consisted of adults between the ages of 21-39 years. This decision was supported by the results of a background study as described in Chapter 4 (Background Study) and is further discussed in Chapter 8 (see section 8.2 The Quantitative Evaluation).

Game-based learning frameworks targeted at adults learning independently are less common in comparison with those addressed to children learning in formal contexts (Whitton, 2010). Similarly, most theories of instructional design are predicated on the idea of learning taking place in a classroom between the instructor and the students (Sharples et al., 2005). Mobile learning however is exactly that; mobile in terms of space, areas of life and time (Vavoula & Sharples, 2002) and indicates a departure from traditional learning models, since learning can easily be carried out and embedded into the everyday environment (Vavoula & Karagiannidis, 2005). Although this view of learning does not exclude formal education contexts however, it is particularly pertinent to everyday, informal learning (Vavoula & Sharples, 2008). This research thus focuses on learning that is independent and learner-directed, taking place in informal contexts.

Furthermore, mobile game-based learning frameworks emerging in the literature seem to primarily focus on either the contextual-learning opportunities of mobile technology (e.g. context-awareness, location-based learning, augmented learning, etc.) or the collaborative opportunities (e.g. communication, sharing and social interaction). In this context games are often used as the tool to deliver mobile learning and not necessarily as the overarching learning strategy. An opportunity therefore exists in investigating mobile game-based learning frameworks where games are used as the primary learning strategy and can be used to support the development of skills for individual learners. This research thus aims to advance

design strategies to inform the development of engaging and usable mobile games, which are able to support individual learners develop their skills.

This work highlights connections between theories of learning and game characteristics, and considers the types of games and learning outcomes that could be facilitated by mobile learning games. Andragogy, which describes adult learning theory (Knowles, 1998), is the foundation of the investigation and the starting point of the discussion of learning theories that support the use of mobile learning games (see section 2.1.1 Adult Learning). The work also undertakes initial background research with adults, to investigate their attitudes towards learning with a mobile game. Furthermore, it develops a framework for mobile game-based learning and advances design guidelines, based on theories of learning, engagement, mobile usability and game design. Finally, it considers methods for evaluating mobile game-based learning.

The work also applies the theory to the design of a working game prototype entitled *Lexis* that is able to support the acquisition of English academic vocabulary. As further discussed in Chapter 6 (section 6.1 Game Genre and Subject Area), language learning and specifically vocabulary acquisition is selected as an appropriate area for the context of independent learning via mobile games. English academic vocabulary is perceived as a suitable learning outcome for adult language learners interested in enhancing a specific sub-set of their existing vocabulary, in order to strengthen their speaking and reading comprehension in either an educational or a professional setting (see section 6.1.2 Learning Outcomes). *Lexis* is a puzzle game developed based on a behaviourist approach to learning (see section 6.3.3 Language Learning Theory), which is considered suitable for mobile game-based microlearning for vocabulary skills development, where continuous independent practice is supported by shorter, interruptible play sessions occurring in spaced intervals. A mini-puzzle games architecture is adopted for the final version of the developed prototype (see section 6.3 Designing Lexis), to support a behaviorist approach to learning based on cycles of drill and practice facilitating repetition and reward (Sharpley et al., 2013).

The developed game prototype is then being evaluated with potential users, to assist quantitative and qualitative data collection, indicating the effectiveness of the game and providing insight into the perceptions and experiences of the evaluation participants. This way the study combines theory development with experimental design work to provide an insight into the potential of adults developing their skills, via mobile games.

1.2 Theoretical Influences

This research is grounded on the design of mobile game-based learning. Theoretical influences for this work therefore draw upon three distinctive areas of study, including independent adult learning, game design and mobile applications (User Experience and User Interface design). More specifically, the research is informed by the intersections of these areas, which are game-based learning, mobile learning design and mobile game design (see Figure 1-1 below).

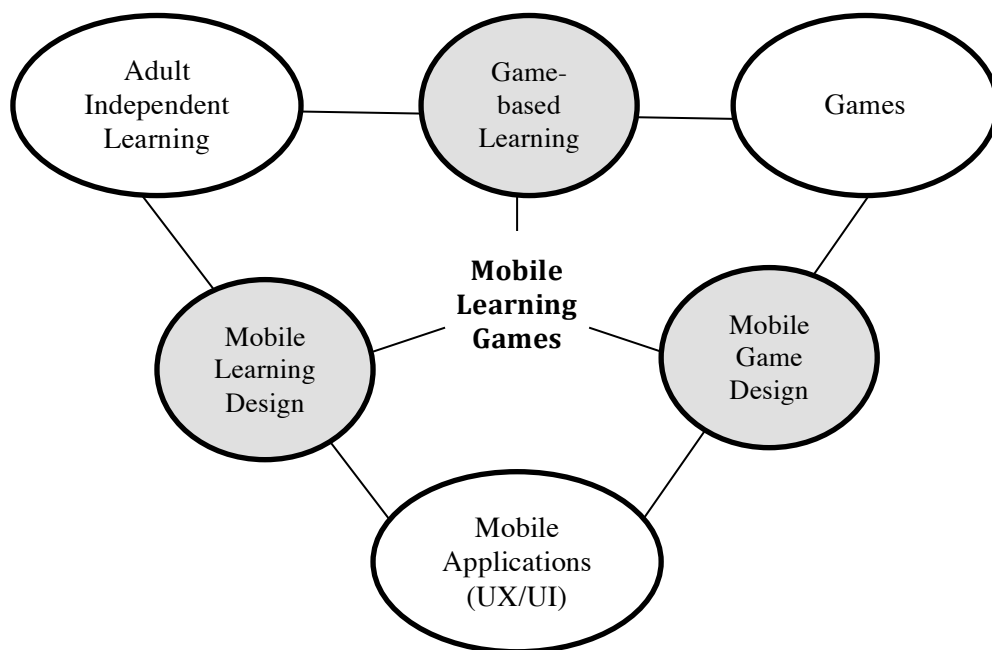


Figure 1-1: Theoretical influences of the research and their intersections

A range of learning theories applicable to the context of independent adult learning are examined in the first section of Chapter 2 (Literature Review), which provides an andragogical rationale for the use of mobile games for learning. It also highlights links between adult learning theory (Knowles, 1998), self-directed learning (Knowles, 1975), mobile learning (Traxler, 2007; Naismith et al., 2004), microlearning (Gabrielli et al., 2006; Cowan, 2011), informal learning (Vavoula et al., 2009) and lifelong learning (Sharples, 2000), in the context of mobile learning environments.

Following, the second section of Chapter 2 (Literature Review) moves on to discuss game-based learning and the potential benefits of using games for the learning of contemporary adults. Furthermore, this section considers the changing learner profile (Prensky, 2001), the characteristics of games that may lead to increased engagement (Malone, 1980a; Csikszentmihalyi, 1992) and the learning principles embedded in games (Gee, 2007; 2005). Game-based learning literature underpins various discussions throughout this thesis, including a definition of games (section 2.3.1 - Chapter 2: Literature Review), the proposed framework of mobile game-based learning (section 2.4 - Chapter 2, Literature Review) and a consideration of the types of games and learning outcomes suitable for the framework (section 6.1 - Chapter 6, Designing Mobile Game-Based Learning).

The third section of Chapter 2 (Literature Review), discusses mobile games. It begins with a characteristics-based definition of games, and moves on to a brief history of mobile games and an overview of game genres, which are then revisited in the discussion of game types and learning outcomes (section 6.1, - Chapter 6 Designing Mobile Game-Based Learning). It also draws on the field of casual games (Juul, 2009) to inform the design of mobile game-based learning for adults, which needs to be appealing to a wider range of audiences.

Theory on the design of mobile learning games is presented in Chapter 5 (Developing Design Guidelines for mGBL) and draws on literature on mobile learning design (section 5.1.1 Design Guidelines for Learning), engagement in game-based learning (5.1.2 Design Guidelines for Engaging Learning Games), mobile games usability (section 5.1.3 Usability Guidelines for Mobile Game Interfaces), and mobile game design (5.1.4 Game Design Guidelines for the Mobile Platform). The guidelines synthesised based on the above theory provide a foundation for the design of mobile games for learning and have informed the development of *Lexis*, a game prototype developed as part of this research, targeted at the development of English academic vocabulary skills (see section 6.3 Designing *Lexis*). The design of the prototype was further supported by theory on game genres and learning outcomes suitable for mobile games (section 6.1 Game Genres and Subject Area) as well as language learning theory (section 6.2 Language Learning Games).

User experience for mobile applications underpins the development of the usability guidelines for mobile learning games (section 5.1.3 Usability Guidelines for Mobile Game Interfaces) and informs the design of the developed game prototype (section 6.3 Designing *Lexis*). These principles of mobile user interface design have also been embedded into the development of the game prototype, as discussed in section two of Chapter 7 (Developing Mobile Game-Based Learning). Furthermore, a number of evaluation methods were used to examine system functionality, usability and engagement including expert reviews and play testing (section 7.1.2 Expert Review and Fixes), as well as questionnaires and interviews as described in Chapter 8 (Evaluation).

The emerging field of mobile game-based learning, which is where this research is situated, stands at the intersection of the disciplines presented above and is informed by all of them. Another overarching theme that emerges throughout this thesis and relates to the theoretical foundations of the work is independent learning. Mobile game-based learning in the case of this research is informal and adaptable to individual learners, allowing them to develop their skills independently, facilitating flexibility and self-direction.

1.3 Research Questions and Aims

The research described in this thesis aims to investigate the rationale for mobile games as a valid tool for adults learning independently as well as whether mobile games are considered acceptable by a wide range of adult learners and consider ways they can be effectively designed and developed to be engaging, usable and to assist learning.

The research focuses on adult learners who may be assumed to exhibit greater independence and the need for self-direction (Knowles, 1998) and who are likely to value flexibility and the division of learning content into manageable chunks, due to various life commitments and limited free time. Adults also come from a range of backgrounds and have different experiences (Knowles, 1998) and thus a learning solution addressed to them should be engaging, appealing to a diverse audience, easily accessible and adaptable to a number of skill levels. It is therefore argued that a mobile game can potentially address those needs via game mechanics, casual values, mobility and built in gameplay adaptability. As previously mentioned in this chapter, mobile game-based learning is a growing area of study that is however still in its infancy, and thus requires further research, empirical data gathering and proposed frameworks addressing different learning contexts.

The primary hypothesis of this research is that mobile games could be effective learning environments that are able to support adults developing their skills independently. To evaluate the validity of this hypothesis and to investigate the potential of mobile games as independent learning environments for adults, three major research questions had to be explored:

- Q1.** Is there a rationale for the use of mobile games in independent adult learning?
- Q2.** How can mobile games be designed to be usable, engaging and support learning?
- Q3.** What would be possible good strategies for evaluating mobile learning games?

Each of the above research questions formulated a key area of work that is further explored in the chapters of this thesis. In investigating these questions, a number of research methods were employed, which are further discussed in Chapter 3 (Methodology). Additionally, in addressing the second research question, a practice-based approach was adopted and thus a working mobile game prototype entitled *Lexis*, was designed and developed (see section 6.3 Designing Lexis). Furthermore, in addressing the third research question and informed by the novelty of mobile game-based learning as a research field, quantitative and qualitative data on the effectiveness of the developed mobile game prototype were collected. These were then used to draw empirically derived conclusions on the perceptions and attitudes of adults towards using the game prototype.

The following section on research design, describes the methods employed to investigate each of the research questions presented above.

1.4 Research Design

As a research domain, mobile game-based learning draws heavily on theory but is also strongly rooted in practice since it concerns the design, development and evaluation of mobile gaming technology. It is therefore important, when investigating mobile game-based learning, to focus on both its theoretical and practical aspects. To meet this dual objective, the research was structured in three phases which were theory development, prototype development and evaluation. The theory development phase was related to the first two research questions. The prototype development phase was rooted in theory developed during the first research phase and related to the first research aim, which was the development of the game prototype. Finally, the evaluation phase was related to the third research question and the second research aim, which was data gathering.

To examine the research questions, a mixed-methods approach drawing on both quantitative and qualitative data collection and analysis methods was utilised. This mixed-methods approach was adopted since the aim of the study was to look into both measurable and in-depth data to provide a more comprehensive picture of the study area. The research approach adopted for this work is further discussed in Chapter 3 (Methodology). The methods utilised to address each of the research questions are however considered below.

Q1. Is there a rationale for the use of mobile games in independent adult learning?

The first research question investigated whether mobile games were appropriate for adults learning independently and examined the attitudes of potential users of such systems, towards learning via a mobile game. To address this question a literature review followed by a background study was conducted.

The literature review, which was conducted first, fed into all subsequent areas of the work. The review was conducted in the areas of study that have influenced this research (see section 2.1). Additionally, a review of commonly used research methods in the fields of game-based learning and game studies was conducted and informed the methodology adopted for this study.

The literature review was followed by a background study, in the form of a large-scale online survey. The survey examined the perceptions and attitudes of adults towards mobile devices, mobile gaming and the acceptability of mobile games as learning environments.

This stage of the research provided the rationale for the use of mobile games as learning environments addressing adults, and supported further study into the area of mobile game-based learning. It also provided some initial data on the preferences of potential users, which then influenced the design of the developed game prototype.

Q2. How can mobile games be designed to be usable, engaging and support learning?

The second research question investigated the development of good design practices for mobile learning games, able to support adults to develop their skills independently. The two pieces of work conducted to address this, were a review of existing theory and a review of selected case studies.

The review of existing theory focused on the examination of extant design strategies, looking at previous work done in the fields of learning design, engaging game-based learning, mobile usability and game design. Theory extracted from the review was then synthesised and informed by the literature review conducted in the previous stage of the research, to then form the final set of proposed design guidelines for mobile learning games.

Furthermore a review of case studies took place as the second piece of research to inform the development of the proposed design guidelines. Eight (8) popular mobile games were selected and reviewed with regard to their gameplay and interface to extract good design practises.

This stage of the research led to the development of four sets of guidelines for the design of mobile learning games, focusing on learning design, engagement design, interface design and gameplay design. The four sets of guidelines were revisited at a later stage to inform the design of the game prototype, which was developed to reflect these proposed strategies as much as possible.

These two pieces of research also supported one of the aims of the study, which was the development of a working game prototype intended to support adult language learners build their English academic vocabulary skills. The game prototype developed was entitled *Lexis*, and it was a mobile puzzle game (see section 2.3.3 Mobile Game Genres, for genre classification).

Q3. What would be possible good strategies for evaluating mobile learning games?

The third research question focused on good practices for the evaluation of mobile learning games. Ways of evaluating learning were examined along with mobile specific evaluation considerations and the measurement of engagement and usability were decided as indicators of learning from the game (see section 8.1 - Evaluating *Lexis*). Two pieces of research then followed, a quantitative and a qualitative evaluation of the game prototype.

The quantitative evaluation was conducted with fifty (50) participants and looked into player engagement and design effectiveness (see section 8.2 The Quantitative Evaluation). It involved the participants play testing the game and then completing a Likert scale questionnaire, which was made up of self-perception questions on how engaging and usable the system was.

An additional qualitative evaluation was also conducted with twenty (20) participants (see section 8.3 The Qualitative Evaluation). The qualitative evaluation involved additional evaluation activities including thinking aloud while play testing as well as a time on task experiment and an interview. The aim of the qualitative study was to extend the quantitative one and to examine participants' thoughts and experiences while playing the game, as well as their post-experimental reflections.

These two types of evaluation conducted also supported the second aim of the research, which was the collection of quantitative and qualitative data on the effectiveness of the developed mobile game prototype, drawing empirically derived conclusions on the perceptions and attitudes of adults towards using the prototype for developing their skills.

As discussed further in Chapter 8 (Evaluation), direct learning was not evaluated and a case was made for evaluating engagement and usability instead in order to assess the effectiveness of a mobile game-based learning application (see section 8.1

Evaluating *Lexis*). It was however felt important to attempt to identify possible indications or learning that could emerge via the examination of the data collected in various stages of the above mentioned two type of evaluation. An investigation was therefore also conducted which provided some positive results as to indications of learning from *Lexis* (see section 8.4 Indications of Learning).

1.5 Research Contribution

This research makes four contributions to knowledge in the area of mobile game-based learning (mGBL). The first is a rationale for the use of mobile games in certain learning situations targeting adults as well as insight into the application of game-based learning to the mobile context. In this thesis an andragogical framework where learning happens independently in an informal context and is learner-directed and adaptable to the individual, is synthesised. Furthermore, this work is positioned on the intersection of the areas of adult learning, game-based learning, mobile applications and game design; a research field new to academic study informed by rapidly evolving mobile technology. Finally, in this research theory informs and is being informed by design thus providing a practise-based approach to mobile game-based learning research, which is scarce in academic literature.

The second contribution is a set of design guidelines able to support the development of engaging and usable mobile learning games, grounded in extant cross-area literature on independent adult learning, game-based learning engagement, mobile usability and mobile game design. As a result of this research, a practical tool is thus provided which is intended for use in the design of similar applications, which could equally be utilised by researchers and designers.

The third contribution is a working prototype of a mobile game-based learning technology developed using the above set of design guidelines, targeted at adults looking to develop their academic English vocabulary skills independently.

The final contribution of this research is an evaluation of the mobile game-based learning prototype using both quantitative and qualitative methods to investigate its overall effectiveness, measure engagement and usability and provide insight into adults' perceptions, attitudes and experiences of using the system.

Overall, this thesis aspires to contribute to the growing body of research on the area of mobile game-based learning, as an area under development that is new to academic research. It hopes to have provided a starting point for further investigation in the area of mobile learning games design, which could be further explored in future research projects.

1.6 Thesis Structure

The body of this thesis is made up of nine chapters. This section provides an overview of the contents of each chapter.

Chapter 1: **Introduction**, provides an overview of the research area and discusses theoretical influences, research phases, activities and contributions.

Chapter 2: **Literature Review**, provides the theoretical background of the thesis and draws on the areas of andragogy, mobile learning, game-based learning and mobile game design. It also looks into theories of learning that have influenced the work, provides a characteristics-based definition of games and discusses mobile game genres and casual game values.

Chapter 3: **Methodology**, describes the overall research design of the thesis and considers the phases and the methods used for data collection and analysis during each phase. Then the chapter moves on to discuss the ethical considerations of the work, as well as the limitations of the study.

Chapter 4: **Background Study** describes one of the early research activities undertaken to examine mobile devices' circumstances of use and adults' perceptions of learning with a mobile game. The chapter begins with an overview of the data collection method adopted, which was an online survey. It then moves on to discuss the survey design and the results of the study, along with their implications for the rest of the research.

Chapter 5: **Developing Design Guidelines for mGBL**, begins with a review of existing design strategies relevant to learning design, game-based learning engagement, mobile usability and mobile game design. It then moves on to discuss the review of existing mobile games to extract good interface and gameplay design principles. Finally, four sets of design guidelines for mobile learning games are synthesised and presented.

Chapter 6: **Designing Mobile Game-Based Learning**, examines the types of games and learning outcomes that might be suitable for the context and presents a rationale for the game genre and subject area selected for the developed game prototype *Lexis*. It then moves on to discuss language learning games and vocabulary development. Finally, it describes the design process of *Lexis*, the developed mobile game-based learning application.

Chapter 7: **Developing Mobile Game-Based Learning**, begins with a review of the design guidelines presented in Chapter 5, against the design of the developed game prototype *Lexis*. Then, it moves on to discuss the development of *Lexis*, including the expert review and fixes that took place in between the initial and final version of the game as well as possible future developments.

Chapter 8: **Evaluation**, is concerned with the evaluation of the game prototype. The chapter begins by discussing ways of assessing learning games and also considers mobile learning evaluation implications. It then describes the mixed-methods evaluation approach adopted for *Lexis* and discusses the evaluation results.

Chapter 9: **Conclusions**, discusses the overall findings of this research and the implications of the study regarding the area of mobile game-based learning, targeted at adults. It also provides a critique of the research methods and proposes possible future directions.

Overall, this thesis investigates the area of mobile game-based learning and develops theory and practical tools regarding the design of mobile learning games, targeted at adults learning independently. It primarily aims to address the three research questions and two research aims proposed in section 1.3 (Research Questions and Aims) and provides insight into the potential of mobile games as effective learning environments to support independent skill development.

The next chapter of the thesis presents the initial step of the research, which was a literature review of the areas of study that have influenced the work. The literature presented throughout the chapter provides a theoretical background for the rest of the research and underpins other activities undertaken, as described in the following chapters.

Chapter 2

Literature Review

This chapter presents a literature review in relation to games and learning in a mobile context. Literature discussed here provides the theoretical background for the rest of the research. The review begins by looking into theories of learning that underpin this work, then discusses literature on games as learning environments and finally examines mobile games, their characteristics and casual values. In the last section of this chapter, theory extracted from the literature is drawn together to inform the proposed mobile game-based learning framework and to provide a rationale for the use of mobile games for adult learning.

There is currently a growing amount of research concerned with the application of mobile technology to learning. Mobile media have become increasingly relevant due to the widespread adoption of mobile devices into everyday life, coupled with their rapidly increased capabilities. The various affordances of mobile technology for learning have been supported by literature (Klopfer et al., 2002; Traxler, 2007; Kukulska-Hulme et al., 2007; Sharples, 2009). A particular opportunity is argued to exist for mobile learning frameworks outside traditional formal learning settings (Sharples et al., 2002), since learning is taking place “anywhere and at anytime” (Geddes, 2004). Furthermore, education methods can be enhanced by the increasing use of ubiquitous gaming technologies, particularly due to games’ ability to appeal to a wide population (Arnab et al., 2015). Kukulska-Hulme and Pettit (2008) argue that the rising importance of informal and lifelong learning is connected to the affordability of mobile technologies, which provide opportunities to embed learning in everyday environments and support skills development across contexts (Klopfer et al., 2002). With the increasing use of mobile devices, mobile games are also becoming more popular and mobile game-based learning emerges as an interesting area of application for the training of the members of “a new mobile society” (Traxler, 2007, p.5).

The inception of educational computer games dates back to the 1960s (Wolfe & Crookall, 1998) and since then, literature has been developing on the different ways in which computer games can be used for learning and teaching in various settings. A new typology of digital games has thus emerged which are designed with a primary pedagogical goal and these are entitled 'serious games' (SG) (Arnab et al., 2015). Literature supports the educational potential of games (Gee, 2007; Aguilera & Mendiz, 2003; Baker et al., 2010, Knight et al., 2010) and proposes links with intrinsic motivation and increased engagement (Malone & Lepper, 1987; Prensky, 2001; Oblinger, 2004). In an evaluation of mobile game-based learning, Schwabe & Göth (2005) found that it provided highly motivating learning experiences. Although games have been found to have substantial potential for learning (de Freitas, 2006) however, for that potential to be effectively utilised, specified learning objectives have to be met. This demands a better understanding of the design of game-based learning applications for particular contexts addressing different types of learners. The main issue with designing educational games is the inadequate integration of learning and game design principles (Lim & Louchart, 2011). According to de Freitas and Liarokapis (2011) therefore, despite the potential of digital games in terms of immersion and engagement, work must still be done to understand how to better design, administer and evaluate them across various learning contexts and targets.

The mobile game-based learning framework developed and proposed in this research targets adult learner owners of mobile devices, such as smartphones and tablets. Learning in this context is independent and takes place in informal settings, since it can occur anywhere and at any time the learner chooses. More specifically the learning environment is a mobile game, designed to support the learners to develop their skills in a self-directed way. Though informal, learning is still intentional on the part of the learner, who understands that the activity undertaken will lead to the development of particular skills. Informed by device ownership, learning is individualised in that the system is adaptable to the individual. In this context skill development is considered lifelong since it is on-going, voluntary and self-motivated.

With the mobile learning field still relatively immature (Park, 2011), and mobile game-based learning still in its infancy as an area of academic research, there is a need for a deeper understanding of the opportunities of mobile game-based learning frameworks in different contexts, as well as the design principles of mobile learning games. Due to the novelty of the field and in light of the absence of an established mobile game-based learning theory, this research looks into other learning theories which have influenced the work and provide the theoretical background for the rest of the research. Following, a number of those learning theories as they relate to mobile game-based learning are considered, in order to provide the foundation for further consideration of the theory and design of mobile game-based learning.

2.1 Adult Learning in a Mobile Context

This section examines theories of learning which support the use of mobile games as learning environments for adults developing their skills independently and which have influenced the research presented in this thesis. Considering there is no one single theory of mobile learning (see section 2.1.2), it was necessary to examine and draw together different learning theories that frame the foundation of the investigation. Such theories include adult learning, which is the starting point of the discussion, as well as mobile learning, microlearning, lifelong and informal learning.

2.1.1 Adult Learning

This research investigates mobile learning games targeted towards adults, in a context where learners develop their skills independently in informal contexts. It is therefore important to look into the factors that influence the learning of adults and make a distinction from school-based learners. This way, the possible learning approaches and motivations of adults could be appreciated and the potential of mobile game-based learning frameworks addressed to them, could be explored. Andragogy, which describes adult learning theory (Knowles, 1998), was thus considered to be a good starting point. Knowles (1998) has described the key premises of adult learning as follows:

- Adults need to know why they need to learn something.
- Adults need to self-direct and take responsibility for their learning.
- Adult learners have a wide variety of experiences and backgrounds and they do not all come from the same starting point.
- Adults are motivated to learn when what they are learning will help them cope effectively with real-life situations.
- Adults are task-oriented and learn things best in the context of using them.

(Adapted from Knowles, 1998)

The theory of Andragogy as described by Knowles, is compatible with earlier educational psychologists like Dewey and Vygotsky who shared a similar constructivist approach (Taylor-Nelms & Hill, 2014). Before Knowles, Simpson (1980) had drawn attention to the two main traits of adult learners, which were the need to be autonomous and self-directing and the use of their past experience as a resource. Rogers (1989) also summarised a number of practical factors that contribute to effective adult learning, most of which comply with the theory of andragogy and support adult learners needs as proposed by Knowles. These factors include learning that is relevant to real life, the need of adult learners to control the pace of their work based on learning in previous experiences, breaking learning down into manageable chunks and creating an awareness of the meta-cognitive processes associated with learning (Rogers, 1989). Smith (1982) supported that the developmental stages of the learner generate different conditions for learning and made six observations of adult learning being lifelong, personal, involving change and involving experience, being part of human development and being partly intuitive. Considering the above, it becomes apparent that self-direction emerges as important in the context of adult learning, which is a lifelong process (Knowles, 1990).

Knowles described self-directed learning as the process in which “individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning,

choosing and implementing appropriate learning strategies, and evaluating learning outcomes” (1975, p.18). He also argued that those adults, who chose to take up learning, are motivated, learn better and tend to retain knowledge for longer periods of time (Knowles, 1975). Merriam and Caffarella (1991) pointed out that self-directed learning moves away from the formal learning paradigm and is often associated with a change in life circumstances that provides the opportunity to take up new learning. Self-directed learning could therefore be associated with independent learning frameworks where adults learn informally.

Independent self-direction also emerges as an appropriate approach, when considering that adults have increased barriers to enter learning, in comparison with younger learners. This is because they lead complex lives and often have various roles to fulfil, which inevitably account for increased professional and personal responsibilities. Increased life commitments which come with adulthood, tend to result in less available time to devote to learning participation, especially in connection with formal educational programs, which are less flexible. Learning frameworks addressing adults should therefore foster flexibility, eliminate barriers as much as possible and allow them to balance learning with other life commitments. Mobile learning can facilitate this need by enhancing self-directedness, shifting time and space constraints and allowing the adult learner to decide where, when and for how long a learning session will take place. However, an additional challenge that comes with independence and self-direction is the possible lack of motivation.

Adult learners today can be considered as lifelong learners, who are individuals interested in learning during their professional life but not able or interested to learn in educational institutions (Manganello, 2013). Lifelong adult learners tend to have a readiness to learn and an orientation to learning, which creates a fruitful context for learning (Knowles et al., 2005). However, they need to be motivated to take up new learning. Lieb (1991) suggested that one of the best ways to motivate adults to learn is to enhance their reason for taking up learning and to eliminate their barriers, which links to the above discussion. Apart from the need for flexibility therefore, six other factors, which could act as sources of motivation for adult learners have been

proposed to be: social relationships, external expectations, social welfare, personal advancement, general escape/stimulation and cognitive interest (Lieb, 1991). Relevancy is also key to motivating adult learners, who need to know how the new learning will help them address a need and see how it relates to the life situation they are currently in (Knowles, 1998). Knox (1977) supported that adults learn continually and informally as they adapt to their changing life roles throughout their lives. Common motivators for adults therefore could include assisting the adaptation to changing life roles, building up a skill required at a certain stage of life, achieving professional or personal development and maintaining/enhancing existing skills through practice. Assuming that motivation is key to adult learning could lead to the consideration of game-based frameworks as suitable for potentially engaging adults in learning activities. It is also important to acknowledge that adults can often be practical in their learning approaches, especially when looking to address a specific need. In this context, providing them with stimulation through a mobile game specifically designed for practical skills development, can tap into their intrinsic impetus and enhance motivation. This can be achieved by aligning learning and game objectives thus allowing skills to be developed incidentally, as adults find solutions to progress in the game.

To conclude, here it is argued that adult learning through mobile games could address the needs for flexibility and independence and is associated with informal learning contexts. It is however important to note that andragogy as a theory of adult learning also comes with criticism. One of the main arguments against it is the opposition to pedagogy and the dichotomy that is implied between adult and child learners and their learning needs. Through this dichotomy, pedagogy is implied as dependant and of little worth in comparison to andragogy (Smith, 2010). The attributes Knowles assigns to the adult learner however are not necessarily distinctive and bring out what is a conceptualisation of education itself, not directly related to age (Jarvis, 1985). Furthermore, clarity is not provided on whether andragogy is a theory of learning or a model of teaching, or whether it is a set of guidelines for practice (Hartree, 1984). Knowles' theory is however considered to include some important insights, which are not however tempered by thorough

research (Jarvis, 1985). These possible weaknesses of andragogy are acknowledged here. It is however argued that the theory can still provide some useful ideas on individualised, self-directed learning that is relevant to the mobile game-based learning framework constructed, and thus to an extent informs this research in relation to the possible expectations of adult learners.

The following section looks into mobile learning and its characteristics and considers a number of reasons that make mobile devices attractive for the independent learning of adults.

2.1.2 Mobile Learning

In today's world the availability of mobile technology is taken for granted. This 'taken for grantedness' as described by Ling (2012), is tied to the idea that nowadays we expect others to be reachable via their mobile phones, while simultaneously others expect us to be reachable as well, and as a consequence mobile devices are carried around irrespectively of where individuals are going. This rapid rate of adoption of mobile technology into everyday life coupled with the social changes that follow cannot but have an impact on how people learn as well. Mobile devices increase the pervasive and ubiquitous potential of play, games and learning by making them available at all times (Bouca, 2012). Learning is therefore increasingly becoming mobile in terms of space, between different areas of life and with respect to time (Vavoula & Sharples, 2002). Over the past few decades there has been a growing interest amongst researchers and application developers in understanding and exploiting the opportunities of mobile technology to enable innovative forms of learning. Vavoula and Karagiannidis (2005) write that recent developments in mobile technologies indicate the departure from traditional learning models, since learning can easily be carried and embedded into the everyday environment. They also point out that the context in which mobile learning is emerging is relevant to learning experiences that are just-in-time, just-enough, on-demand, personalised and seamlessly integrated into everyday activities (Vavoula & Karagiannidis, 2005). The

way this learning is facilitated is being informed by the needs of contemporary learners as well as the circumstances of use of mobile technology.

Accessibility and flexibility are key characteristics of mobile learning, which is free from spatial and temporal restrictions. At the same time handheld devices are relatively inexpensive, facilitate access to information and offer possibilities for both collaborative and independent learning (O'Maley et al., 2003). Mobile devices therefore emerge as an attractive technology for future learning frameworks addressing the members of a mobile society.

Mobile devices today are powerful and bring various opportunities including web browsing, image and video capturing, geo-location positioning services, etc. (Bohmer et al., 2011). They are therefore more than 'just cellphones' since they afford more than calling, receiving calls, texting and receiving text messages (Bouca, 2012). They can be used to generate and share content, communicate, access information and for gameplay, all of which become interesting affordances for learning. Downloadable content can also be used for learning purposes, since users can access and use learning content, which can be frequently updated in order to provide up-to-date training. Web browsing capabilities and mobile optimised web content can also provide opportunities for on-line learning, on-demand access to information, sharing and matching of content, etc. Finally, global positioning system (GPS) technology embedded in mobile devices has provided an avenue for innovative context-aware educational frameworks, where learners use their current location to access and bookmark content. Finally, most mobile devices offer gesture-based interfaces and feature accelerometers and touch screens, which make interaction more intuitive and comfortable for the majority of users. This is an interesting affordance for learning, considering that studies suggest the effectiveness of the learning process when combined with bodily movements as well as the enhanced concentration levels that hands-on work offers to learners (Hein, 1996; Gardner, 1993). Interestingly, bad perceptions of technology usage are reduced when it comes to using mobile devices. According to Jones, Issroff and Scanlon (2007), although a number of learners do not prefer to use computers for learning, they do not oppose to the use of mobile technologies, therefore it seems that the anxieties or

lack of confidence that users experience with static technologies, do not apply to the same extent to mobile devices. It can thus be argued that the motivational appeal of mobile devices stemming from comfort of use is higher than that of other technologies.

Although interest in mobile learning is growing, a set definition does not yet exist. A simple and inclusive definition would be one that describes mobile learning as learning mediated through mobile technologies (Winters, 2006), or according to Traxler: “any educational provision where the sole or dominant technologies are handheld or palmtop devices” (2005a). This type of definition can relate to almost any mobile learning project and is technocentric. Technocentric definitions are inevitably linked to mobile technology. However, they are usually not wide enough to include theoretical considerations of learning and do not help with the understanding of the context of learning or the pedagogical perspective of the proposed framework. Traxler (2007) criticises such definitions as they appear: “constraining, technocentric and tied to current technological instantiations” (p.4). An alternative approach would therefore be to look into mobile learning definitions from the learner’s perspective.

When attempting to define mobile learning, the consideration of the learner and his mobility becomes interesting to explore. A learner-centric definition approach recognises the needs of contemporary learners, especially with regards to movement and travel (Kukulska-Hulme et al., 2007). In this context, mobile learning can be defined as: “any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies” (O’Malley et al., 2003). Kukulska-Hulme (2005) also recognises the importance of mobility when discussing mobile learning in which the learners can engage in activities without being constrained to a specific physical location, using mobile devices as a mediating tool for learning. Mobility, portability and situated context have been identified as key features of mobile learning by various researchers (Traxler, 2007; Kukulska-Hulme et al., 2009; Jeng et al., 2010), highlighting the social practices mobile learning

enables, informing and being informed by “a new mobile society” (Traxler, 2007, p.5). Discussing the ‘mobile’ in mobile learning, Sharples (2009) proposes that mobility can be understood in various ways:

Mobility in physical space: people on the move trying to cram learning into the gaps of daily life. The location may be relevant to the learning or merely a backdrop.

Mobility of technology: portable tools and resources are available to be carried around. It is also possible to transfer attention across devices (from laptop to mobile phone to notepad).

Mobility in contextual space: learning topics and themes compete for a person’s shifting attention, which moves from one conceptual topic to another driven by personal interest, curiosity and commitment.

Mobility in social space: learners perform within social groups, including encounters in the family, office or classroom context.

Learning dispersed over time: learning is a cumulative process that happens across formal and informal learning contexts.

(Adapted from Sharples, 2009)

Considering the above, research into mobile learning could be understood as the study of how the mobility of learners, augmented by personal and public technology, can contribute to the process of gaining new knowledge, skills and experience (Sharples, 2009). It therefore becomes clear that although technology does play a vital part in developing mobile learning frameworks and should be considered, defining the wider context of mobility and the needs of the learner is also important to understanding the wider context of mobile learning.

When attempting to construct a mobile learning framework, describing the learning theories that underpin it is key. This is particularly important in the absence of one single mobile learning theory. On the contrary, it is possible that more than one learning theory can inform a particular framework. In fact, Kukulska-Hulme, Pachler and Vavoula (2009) claim that no single methodology can fully describe mobile learning, which is distinctively different to learning in formal settings which occurs in a classroom environment and is rooted in the idea of teaching (Taylor et al., 2006). Taking established learning theories and extending them within game environments is a common approach when describing serious games (de Freitas & Jameson, 2012). Deciding on influential learning theories by case is therefore justified by the various strategies that mobile game-based learning frameworks could support, ranging from classroom augmentation, blended learning, just-in-time learning, context-based learning, game-based learning, etc. Muyinda (2007) also supports that existing learning theories do not fully encapsulate the considerations of mobile learning and therefore a combination of learning theories can be utilised until a universal theory of mobile learning has been developed. In the context of this research it was therefore important to draw together existing theories of learning, which relate to the framework as well as to the wider learning context of adults developing their skills independently via a mobile game. A good starting point was Naismith et al. (2004) who adopt an activity-centred approach and consider new mobile learning practices against existing educational theories. In their literature review they identify six broad theory-based categories of activity, which are considered below:

Theory	Description	Mobile Opportunities
Behaviourist Learning	Activities that promote learning as a change in observable actions.	Association between stimulus and response (drill and feedback).
Constructivist Learning	Activities in which learners actively construct new ideas or concepts based on both their previous and current knowledge.	Embed learners in realistic contexts at the same time as having access to supporting tools.
Situated Learning	Activities that promote learning within an authentic context and culture.	Knowledge presented in authentic contexts while learners participate within a community of practice.

Collaborative Learning	Activities that promote learning through social interaction.	Create an environment in which conversational learning takes place.
Informal and Lifelong Learning	Activities that support learning outside a dedicated learning environment and formal curriculum.	Support intentional and accidental learning episodes.
Learning and Teaching Support	Activities that assist in the coordination of learners and resources for learning activities.	Support personal organisation and administrative duties.

Table 2-1: Mobile technologies for learning (adapted from Naismith et al., 2004, pp. 10-19)

The above categories are not mutually exclusive and are project dependent and so certain activities or frameworks may fall into more than one category. Naismith et al. (2004) propose that the categories can support a range of different activities and are most successful when a blended approach is adopted. Looking at the above categories it was decided that the theory closer to the wider context of the proposed framework of mGBL developed in this thesis, was informal and lifelong learning, which informed the developed design guidelines for mobile game-based learning, along with adult learning.

It is also important to highlight that although mobile learning falls into the category of digital learning and mobile devices are essentially computational machines, they should be recognised as devices with distinctive characteristics rather than a more flexible alternative to static devices. This way the design of mobile learning activities can be truly context-specific and explore the affordances of mobile technology. Klopfer et al. (2002) identified five properties of mobile devices able to produce interesting educational affordances, which are considered below:

- Portability: small size and weight of devices means they can be moved around within or between sites.
- Social interactivity: opportunities for learners to collaborate face-to-face and exchange data.

- Context-sensitivity: ability to gather and respond to real or simulated data, unique to location, environment and time.
- Connectivity: devices can be connected to other devices, data collection devices or common networks to create a shared network.
- Individuality: flexibility for customisation and personalisation for individual needs and users.

(Adapted from Klopfer et al., 2002)

There are therefore a number of factors that make mobile devices attractive for the learning of adults. Foremost, according to Kukulska-Hulme (as cited in Alexander, 2004) device ownership facilitates control over the learning process, allowing for self-direction as well as personalisation of the learning content. Kukulska-Hulme and Traxler (2007a) supported that personalised learning designs are particularly suited to mobile learning, which can effectively facilitate diversity, difference and individuality in the ways learning is developed, delivered and supported. At the same time though, mobile devices allow for collaboration and sharing, since they are essentially communication devices. Due to their portability they are ideal for supporting flexibility in learning and allow learners to have control over their learning schedules. Learners can therefore choose where, when and for how long they will take up a learning session, and can thus develop individually controlled learning patterns. Portability is also one of the most important opportunities of mobile devices, which leads learning outside of formal educational settings and demands new frameworks based on the premises of anywhere, anytime access. Naismith et al. (2004) hypothesise that mobile technologies will have a great impact on learning in the future, which they argue will eventually centre on the individual learner's environment rather than the classroom. Klopfer (2008) also supports the informality of mobile learning and states that mobile devices provide opportunities for learning outside the classroom or a formal setting. Contemplating the nature of mobile content which is meant to be consumed in an "anytime, anywhere" (Geddes, 2004) context, it becomes apparent that mobile learning moves towards less fixed and more informal educational settings. Kukulska-Hulme and Traxler (2007a) support that mobile technology is very well suited to learning described as informal,

opportunistic, ‘bite-sized’ and spontaneous. Mobile learning is therefore spontaneous, private, portable, situated, informal, bite-sized, light-weight and context-aware in nature (Traxler, 2005b) and therefore appears to have strong links with independent adult learning.

Having discussed mobile learning, the next subsection will look into microlearning as it applies to a mobile learning context. Bite-sized learning is well supported by mobile technology, which allows for information to be organised in smaller, manageable chunks that are appropriate for the circumstances of use and technical limitations of mobile devices. Additionally though, microlearning content appears to support learning since according to Miller (1956), due to humans’ limited short-term memory capacity, information should be grouped into meaningful sequences.

2.1.2.1 Micro Learning

Microlearning is based on the idea of developing smaller and manageable chunks of learning content or according to Chen et al. (2015) it is a new learning paradigm where an integral learning resource consists of a series of microlearning units. It therefore describes the process during which learners engage with smaller learning units and focus their learning in small increments (Hug et al., 2006). A growing focus on microlearning activities has been seen with the advent of mobile learning, however there is still a wide space for development since the paradigm is new and currently under-researched (Ren & Zhao, 2010). When microlearning is delivered via flexible technologies such as mobile devices, it can be accessed easily in various contexts and can respond to lifelong learning needs. Applications providing learning micro-content are therefore ideal for mobile devices since they allow learning to be embedded into the on-going activities of daily life. Activities or microlearning are often based on interaction with micro-content, which occupies short time spans. Examples of microlearning activities may include answering a quiz question, viewing a flashcard, reading a paragraph of text, listening to an audio clip or viewing a video clip, etc.

Microlearning has been supported in literature on learning psychology (Simon, 1974) and human cognition, which places the limits of information processing in short-term memory (Cowan, 2001). According to Simon (1974) people can learn better and more effectively when the content is broken down into digestible parts and learning takes place in small steps. When compared with other forms of technology-enhanced learning therefore, microlearning brings specific characteristics. These include the structure of learning content in small units to avoid overflow, the re-design of learning processes according to the small units paradigm and the empowerment of the learner to choose not only the pace but also the time and place of learning (Bruck, 2006). It therefore becomes obvious that microlearning pedagogy focuses on short-term and informal learning activities (Kovachev et al., 2011). However, it is important to note that although micro-content is good for learning environments where learning can be designed in smaller objects, it may not be appropriate for all forms of learning (Bruck et al., 2012). Depending on the type of learning, micro, meso and macro aspects vary and are relational. For example in the context of mobile language learning, which will be discussed further in later chapters, micro aspects may refer to vocabulary training or phrase formation, which is distinctive to complex semantics that could for example refer to a macro aspect of learning a language.

Microlearning is particularly effective in a mobile context. This is because by breaking down information into smaller sections, better usability and interaction facility is achieved in a mobile user interface. Microlearning works quite well with the limitations of mobile devices such as variations in platforms, small screen-size and consistent presentation of information and thus supports the miniaturisation of learning content and learning media (Yuan & Guo, 2013). In this context the importance of device-specific content delivery methods is also highlighted, since the use of large amounts of text or sequences of data often used in traditional e-learning do not necessarily transfer effectively in a mobile platform. Furthermore, mobile devices bring great opportunities for microlearning, since they are highly accessible and portable devices, as previously mentioned.

This supports learners in their access and transfer of learning resources across different surroundings, as microlearning requires (Gabrielli et al., 2006).

Microlearning is a suitable paradigm to be informed by recent learning approaches focused on investigating the characteristics of adult learning during lifelong activities (Gabrielli et al., 2006). In this context learning takes place informally and often relates to the needs of an individual learner to build an understanding or to develop skills that apply to daily professional or personal roles. It therefore has to do with personal development that takes place outside formal learning settings and is based on concise and informed learning activities. In an informal learning context the learner is primarily interested in accessing specific information that support decision-making or the acquisition of a needed skill (Tough, 1971). Mobile applications and games can therefore be designed around microlearning content that is able to support intentional types of informal learning, which assists adults in acquiring new knowledge and skills.

2.1.3 Informal Learning

When considering a mobile game-based learning framework that addresses adults developing their skills independently, the discussion will often lead to informal learning taking place outside formal educational settings. According to Vavoula et al., the idea of mobile learning has always been linked to informal learning due to the capabilities of mobile technology to support personalised, contextualised learning that is controlled by the learner (2009). In independent mobile learning taking place informally, the learner is in control of setting personal goals and tailoring learning around individual needs or interests. In such a context there is no curriculum, teacher, formal feedback, goals or assessment (Vavoula et al., 2009). Because informal learning is learner-centred and controlled, it is more varied and therefore has no clear boundaries. This is especially true for independent learning contexts often linked to personalised learning, owned by the learner.

To date, much of the research on game-based learning environments has focused on formal educational settings and training (Clark et al., 2013; Johnson, 2010), although informal educational settings, can also benefit, perhaps even more so, from advances in game-based learning (Lane et al., 2013; Rowe et al., 2014) and mobile technology. When researching games and learning, it is useful to distinguish between formal and informal learning, however in a mobile context the boundaries are less easy to define. Furthermore, the distinction between formal and informal learning is often used to reflect the context in which learning takes place (Iacovides, 2012) and therefore proposed learning frameworks, including game-based ones, should be examined by case. Vavoula et al. (2009) suggest that by anchoring research findings in the careful analysis of a particular case that can be abstracted to the general, research will enable others to learn and apply the work to different contexts, providing a strong foundation for future research on mobile learning.

Livingstone suggests that informal learning is “any activity involving the pursuit of understanding, knowledge or skill which occurs without the presence of externally imposed curricular criteria” (2001, p.4). He moves on to propose that informal education or training is distinguished as self-directed informal learning in the presence of some form of institutionally recognised instructor (Livingstone, 2001). Vavoula (2004) suggests that informal learning could be defined as a process of learning that occurs autonomously and casually and is not tied to a highly directive curriculum or instruction. Informal learning however can be either intentional, through significant and deliberate learning “projects” (Tough, 1971), or accidental by acquiring information through everyday life experiences and exposure to the environment, etc. According to Eraut (2000), the intent of the learner is important in this context, while intentional activities represent deliberate learning and accidental activities implicit learning. Vavoula (2004) also distinguishes between intentional informal learning, where goals and processes are clearly defined by the learner and unintentional informal learning, where goals and processes are not pre-described and develop as the learning occasion arises.

Literature on informal learning (Tough 1971; Livingstone 2001) reveals that a significant amount of adult learning takes place outside formal educational settings. In addition, there is increased interest in the UK adult education and lifelong learning fields towards informal learning (M. K. Smith, 2008). According to Tough (1971), when people need to complete a task or make decisions they will not need to learn a complete body or subject matter but instead just the skill or knowledge that is useful in dealing with the particular responsibility. This is particularly applicable to adults learning in an informal context since they will often need to learn something to adapt to a new life role, perform a routine task more effectively, undertake an activity and so on. It is therefore important for the medium used to support informal learning, to be seamlessly blended into daily life. Mobile devices are thus ideal to support such activities, since they are already unobtrusively blended in daily life. In addition, mobile devices can be successfully used to monitor the frequency and extent of informal learning episodes, which are otherwise very difficult to detect.

In the context of this research, anywhere and anytime learning through a mobile game is intentional and self-directed (happens voluntarily, on the learner's initiative) while it takes place independently (without the presence of a teacher) and freely (outside any formal educational setting). The informality of the learning therefore has to do with the setting, location and time; however the adult learner understands that an activity which will lead to learning is undertaken. To conclude, this research focuses on mobile game-based learning that is informal in terms of context but also because it is adaptable to the individual player, providing a personalised experience and because it allows player control over where and when to learn.

2.1.4 Lifelong Learning

Although there is no set definition, lifelong learning could be considered as a means of providing contemporary adults with the skills and knowledge they need in a rapidly changing world (Sharples, 2000). Such learning is deliberate and can occur throughout an adult's life; it also consists of any type of learning that people receive

after completing formal education (Nordin et al., 2010). It therefore becomes apparent that lifelong learning is essentially on going, voluntary and self-motivated (DES, 2000). The core premise of lifelong learning is that since it is not feasible to equip people in formal schooling with all the knowledge and skills they will need throughout their lifetime, they will be required to continually enhance them in order to achieve personal development and address life problems (Sharples, 2000). In an emerging knowledge society (Drucker, 1994), adults will need to take up learning as a lifelong process to be considered educated and to remain competitive. A learning society should therefore provide avenues to individuals to seek knowledge (Nordin et al., 2010). An important educational imperative thus emerges and relates to empowering people to manage their own learning in a variety of contexts throughout their lifetime (Bentley, 1998).

The aim of lifelong learning is to improve knowledge, skills and competences from a personal, civic, social or employment related perspective (Yamat et al., 2007). At the core of learning therefore, is the individual learner (Vavoula & Sharples, 2001) and it becomes apparent that lifelong learning needs to be able to address the needs of the individual (Nordin et al., 2010). At the same time, it needs to be flexible and not tied to a particular location. This is because it often occurs whenever there is a break in the flow of routine daily performance and the learner reflects on the current situation, resolves to address a problem, to share an idea, or to gain an understanding (Sharples, 2000). Lifelong learning should be able to allow adults to continually enhance their skills and acquire knowledge that will help them in their personal development.

Rozhan and Hanafi (2007) relate lifelong learning to the use of technology, while specifically mobile technology can be useful in this context, since it can successfully facilitate the aforementioned requirements of lifelong learning. Personal mobile devices can support lifelong learning frameworks that are accessible to all, not restricted by spatial and temporal constraints, and are adaptable to the needs of the individual learner promoting self-direction. At the same time, mobile applications can be designed that are adaptable to user needs, durable and easy to use. Indicating

how lifelong learning and personal technology converge, Sharples (2000) has pointed out that technology becomes more personalised, mobile and durable, thus able to support individualised, situated and lifelong learning.

Lifelong learning sees learning as taking place not simply in schools but throughout life, in many different locations and times (Rogers, 2004). It can therefore happen anywhere, according to the needs of the individual, and is closely related to informal mobile learning paradigms for adults. Justification for the suitability of informal, lifelong mobile-learning frameworks for adult learners comes from Vavoula (in Sharples et al., 2005), who found that 51% of adult everyday learning happens at home or in the office in an anywhere, anytime context, assisted by mobile devices. At the same time, Naismith et al. (2004, p. 5) claim that learning will move more and more outside of the classroom and into the environment of the learner and that it will gradually become more situated, personal, collaborative and lifelong. In this context the unique attributes of mobile devices offer great potential to support lifelong learning (Fischer & Konomi, 2007; Clough et al., 2008, Gu et al., 2011).

In all, the theories of learning discussed above including adult learning, mobile learning, informal and lifelong learning, are closely related in terms of an andragogical stance and are complementary to one another. They allow for flexibility and accessibility, empowering adults to take control of their learning, and catering to their individual needs. The next section will move on to discuss game-based learning as well as the benefits of using games in the learning of contemporary adults.

2.2 Game-Based Learning

When examining mobile learning games for adults developing their skills independently, the suitability of games as a technology for learning should be discussed. This section will therefore examine game-based learning literature and provide a rationale for using games as learning environments.

Game-based learning can generally be described as learning facilitated via a game. According to De Freitas, computer game-based learning applications utilise the characteristics of computer games to create engaging and immersive learning experiences for delivering specified learning goals and outcomes (de Freitas, 2006). In recent years, research on the various cognitive gains games bring, as well as the opportunities they provide for learner engagement, have led to increased interest in game-based learning and its applications to various learning frameworks. Such games aimed towards learning, are often referred to as ‘serious games’ (SGs) or ‘games with a purpose’. SGs are designed with a primarily pedagogical goal (Arnab, 2015) since pedagogy lies at the heart of the distinction of what is considered as games for learning in comparison to other entertainment purposes (Michael & Chen, 2006). Furthermore, in these games knowledge transference is a core part of the game mechanics (Shute, 2009). The inception of games for learning dates back to the 1960s (Wolfe & Crookall, 1998) while their effectiveness as educational tools resides in their strong relation with play, a natural human activity fundamental to the development of both children and adults (Rieber, 1996). The importance of play as a human activity, has been highlighted by Johan Huizinga who argues that culture derives from play (Huizinga, 1949) and Roger Caillois who introduced a system of categories to distinguish different forms of play (Caillois, 1961). The act of play in a computer game can facilitate the evolution of human experience in a safe environment, via providing opportunities to practice skills and explore behaviours that can then be transferred into everyday life (Koster, 2004).

Game-based learning pioneer James Paul Gee argues that: “Video games are good for learning” (Gee, 2007), while Aguilera and Mendiz write: “A number of studies indicate that games are conducive to the development of skills like attention, spatial concentration, problem-solving, decision making, collaborative work, creativity and ICT skills” (Aguilera & Mendiz, 2003, p.8). Today there are various successful examples of games used to assist learning that address both children and adults in various settings, while game-based learning is considered among the educational technologies “to watch for” according to The Horizon Report (Johnson, et al., 2011).

Some of the reasons that support the consideration of games as effective learning environments are the changing profile of contemporary learners, the opportunities for increased motivation and engagement they provide and finally the good learning principles embedded in gameplay. These, frame a rationale for the use of game-based learning, and are discussed below.

2.2.1 Changing Learner Profile

Game-based learning frameworks comply with the profile of contemporary adult learners. Adults playing games is slowly becoming the norm not the exception, while the overall number of gamers increases each year. In the UK, 59% of 6 to 65 year olds play one form of video game (Pratchett, 2005), while 48% of 6 to 65 year olds are heavy gamers, meaning they play at least once a week (BBC, 2005). In the US 59% of Americans play video games and the average gamer is 31 years old (Entertainment Software Association, 2014). At the same time, with digital games now aimed at every age group, half of all European gamers are now aged over 35 and 25% of Europeans play games every week (Sharples et al., 2013). This positive attitude towards game playing could be interpreted considering that many contemporary adults have grown up playing, or at least being accustomed to the idea of computer games. From an educational perspective, people that move into adulthood having grown up with games, computers, the Internet and more recently mobile technologies, could often demonstrate some learning needs that are different to those of the previous generations (Gibson et al., 2008; Tapscott, 2009). Prensky (2001) describes this generation of “digital native” learners as the “Games Generation”, while others have attributed the terms “Net generation” (Oblinger, 2003; Oblinger, 2009) or the “Google Generation” (JISC, 2008). Prensky argues that adults who belong to the games generation use games to learn instinctively, in comparison to older learners who may be more prone to traditional educational strategies (Prensky, 2001). For younger adults gaming technologies are increasingly becoming part of daily life, informing tendencies to utilise them for social aspects of life, like communication, sharing, entertainment, work and learning. Prensky also argues that such learners present cognitive characteristics informed by

immersiveness in technology which has fundamentally altered the way they accumulate and assimilate information (2001). More specifically he describes ten ways the games generation is cognitively different, including processing information faster, focusing on graphics before text, following non-linear paths through learning materials, taking an active role in seeking information and deciding what to learn and expecting quick rewards and quick feedback, among others (Prensky, 2001). Social scientists sustain that today's learners think and process information differently, or even more so their entire system of beliefs is different from those in previous generations and these differences tend to go further and deeper than most educators recognise (Burkle & Cleveland-Innes, 2013). Toledo (2007), argues that even if the digital natives have slight differences in speech and social interactions, they are fluent in digital communication forms. Such cognitive characteristics could be fostered by learning frameworks that are able to support fast-paced, non-linear, self-directed problem-solving as well as visually rich technology-enhanced learning. They could thus be facilitated by game-based learning paradigms, which due to their structural game design features can also assist the development of practical skills in contemporary learners. For example, when learning a complex skill players should first learn the discrete components of that skill individually before practising 'chaining' them together in combinations (Linehan et al., 2014). According to behavioural psychology the problem-solving behaviour in adults is the combination of already learned behaviour (Skinner, 1953; Skinner, 1974) and can be exercised successfully via analysing a sequence of challenges in games the complexity of which correlates with the points at which new skills are introduced (Linehan et al., 2014). The overall effectiveness of game-based learning has been highlighted by Beavis and O'Mara (2010) who argue that: "gameplay is increasingly part of what it means to be literate in the 21st century", while gaming is considered suitable for contributing to the development of a particular disposition that is well suited to an information-based culture (Johnson, et al., 2011) and responds to the changing needs of the games generation.

It is important to recognise however that Prensky's ideas are not based on empirical evidence and thus they should not be uncritically adopted. It should be highlighted that the proposed broad categorisations, homogenising diverse groups of individual learners are not necessarily fully applicable to determine their overall characteristics (Bayne & Ross, 2011). This is understood and accepted, since the aim here is not to claim that all contemporary adults will display the same learning needs and that they will necessarily be positively motivated by the idea of learning via a game, even if they use it recreationally. Prensky's ideas are presented as a starting point to discuss possible cognitive changes in the profiles of contemporary adults, informed by their familiarity with and everyday use of the web, mobile devices and games as suggested by the rapid adoption of such technologies into social life, and to attempt to understand and propose how such social practices could become powerful learning interventions potentially appealing to a wider audience, in comparison to previous years.

2.2.2 Games, Engagement and Fun

Another reason contributing to the popularity of games as learning environments is that they are often considered successful in retaining engagement, keeping the player motivated and facilitating fun. The fact that games are intrinsically motivating has been supported by various literature considered influential in the field of game-based learning (Malone, 1980a; Crawford, 1984; Prensky, 2001; Oblinger, 2004; Paras & Bizzocchi, 2005). More recently, Habgood and Ainsworth (2011) found empirical evidence that intrinsic integration supports learning in serious games. Links between gameplay and intrinsic motivation are important when it comes to pursuing learning objectives to not only engage the learner with the learning content but to also retain the motivation for longer. According to Paras and Bizzocchi (2005), game environments have great potential to support immersive learning experiences due to their motivational benefits. While Chan and Ahern (1999) claim that when people are intrinsically motivated to learn they tend to not only learn more but also have a more positive experience while doing so.

When discussing engagement with regards to computer games, the theory of “flow” is of particular importance (Csikszentmihalyi, 1992). A state of flow describes an optimal balance between the challenge of the game and the skill of the player, where gameplay is considered to be neither too easy nor too difficult, thus retaining the player engaged. In a state of optimal flow the player allocates all his cognitive resources to the game, is fully emerged and enjoys the experience (Prensky, 2001). In the area of games therefore, the theory of flow has a particular value since it maps so well against the process of immersion experienced by players during game-play (Dunwell et al., 2012). The flow theory summarises a number of elements considered important when it comes to player engagement including: challenge in sync with player skill, clear goals, immediate feedback and a sense of control (Csikszentmihalyi, 1992). Achieving flow is necessary in game-based learning since the aim of the learning game is to create so interesting an experience that it holds the player’s attention as long and as intensely as possible (Kiili et al., 2012).

Influential work on games and engagement, has also been produced by Malone (1980a, 1980b) who examined how engaging elements of commercial games can be applied to game-based learning. Although Malone’s work was undertaken with children, it is argued that the general guidelines extracted from his work could apply to adult learners as well. The three original factors he claimed make games engaging are challenge, fantasy and curiosity (Malone, 1980a). A few years later Malone along with Lepper extended these factors and added control, which was broken down to contingency, choice and power (Malone & Lepper, 1987). Prensky (2001), also supported the engaging values of games and argued that they can effectively teach essential 21st century skills. He writes: “computer and video games are potentially the most engaging pastime in the history of mankind” (Prensky, 2001, p. 106) and he provides a list of elements that make games engaging:

- They are fun
- They are a form of play
- They have rules
- They have goals

- They are interactive
- They have outcomes and feedback
- They are adaptive
- They have win states
- They have conflict, competition, challenge and opposition
- They have problem solving
- They have representation and story

Adapted from Prensky (2001, p. 106)

One of the elements that make games engaging according to Prensky is fun, which gives players enjoyment and pleasure. This allows for a receptive frame of mind, which in addition to active play increases involvement and can help learning (Prensky, 2001). Talking about digital games therefore, Prensky (2001) stressed the importance of the application of fun to training and education to increase engagement. Games are according to him great facilitators of fun, which can evoke relaxation to enable learners to take things in more easily, and motivation to enable them to put forth effort without resentment (Prensky, 2001). However Prensky also pointed out a tension associated with the term fun, since it is often considered as something that subtracts seriousness and should not be associated with learning.

Ralph Koster (2004) argued that fun equals learning and claimed that there is no design tension between the two since the human brain finds the process of making sense of patterns enjoyable. He defined fun as: “the feedback the brain gives us when we are absorbing patterns for learning purposes” (Koster, 2004, p. 96). As such, games are learning because the player is constantly seeking to understand the pattern in the game and repeat it until mastery is gained. A balance has to however be achieved because if the pattern is too easy (boredom) or too complex (frustration), players will give up. Koster’s work thus extended flow theory and supported the engaging power of games, as proposed by Prensky. Koster argued that fun in games comes from learning, and the learning is helped by fun (2004).

Discussing the concept of fun in games LeBlanc et al., (2004) proposed eight kinds of fun, which included: sensation (sense-pleasure), fantasy (make believe), narrative (drama), challenge (obstacles), fellowship (social framework), discovery (uncharted territory), expression (self discovery) and submission (pastime). These are not mutually exclusive since several types of fun can be found in games in varied quantities. Different types can also appeal to different players, who are looking for fun in different measures (LeBlanc et al., 2004). This discussion of kinds of fun in games was part of the aesthetics component, one of the three components of the MDA Framework (Mechanics, Dynamics, Aesthetics), which was developed and taught as part of a Game Design Workshop at the Game Developers Conference between 2001-2004 (LeBlanc, 2004).

The table below summarises the previous discussions on fun, as proposed by Prensky (2001), Koster (2004) and LeBlanc et al. (2004):

Prensky	Games are a structured way to harness the power of fun and play in the learning process. Through fun, games can provide enjoyment and pleasure and facilitate relaxation and motivation.
Koster	Fun equals learning and is associated with the process of making sense of patterns. In games, fun comes from learning and the learning is helped by fun.
Leblanc et al.	Aesthetics of play describe the reasons why players engage with games. These can be summarised in eight kinds of fun. Each game pursues multiple aesthetics goals in varying degrees.

Table 2-2: 'Fun' in games

The above work by Csikszentmihalyi, Malone, Prensky, Koster and LeBlanc et al. can support the engaging potential of game-based learning. It is therefore argued that games could potentially be successful to facilitate fun and engagement in learning. Furthermore, the next subsection will discuss possible good learning principles embedded in games.

2.2.3 Learning Principles Embedded in Games

As previously discussed in this thesis, one of the reasons why games can be effective as educational tools is their strong relation with play, a natural human activity fundamental to the development of both children and adults (Rieber, 1996). It is however important to highlight that the focus of the discussion is on digital games played on personal computers, consoles and mobile devices, rather than other types of traditional games (e.g. board games, role playing games etc.). According to Bjork, digital games draw most of the attention due to the: ‘ability of computers to handle complex sets of rules and game states, their capability to provide captivating audio and video, being able to play with people in other cities or countries but also being able to play against the computer rather than a person’ (2013). Digital technology therefore and the ubiquity of computers, has an impact on what games are possible to make and how these games are played (Bjork, 2013). In common usage therefore, digital games are those played or mediated by computers (Bjork, 2013) and these are the types of games the learning principles embedded in which, will be examined in this section.

Gee (2007) points out that a lot of good learning principles are embedded in games, which are very successful in teaching people new transferable skills. Transfer is important when it comes to learning technology, since being able to apply newly acquired skills in real life settings is key for all learners. In his 2005 book: ‘Why Are Video Games Good for Your Soul: Pleasure and Learning’, James Paul Gee claims that games externalise the way the human mind works better than all other technologies available in that they are the perfect metaphor of the mind as a simulator. They provide a visual and auditory world to manipulate and reset, and thus prepare people for the actions needed to accomplish goals (Gee, 2005). Gameplay is separate from reality since it takes place within agreed borders, thus allowing players to test hypotheses within a safe environment (Wechselberger, 2014). What guides players towards the accomplishment of goals in games are the design affordances as specified by the game designer. Different types of games are therefore best suited for different types of learning. For example, trivial pursuit

games can help fact learning, or puzzle games can exercise pattern recognition (Gee, 2005). Game environments are very successful as experimental techniques since they have negotiable consequences (Wechselberger, 2014). This is because games do not punish risky behaviour and are ideal for facing challenges in the repetitive safety of simulated environments (Digman, 2011). They therefore become “great practice for real life” (Beck & Wade, 2004, p.75). According to Edery and Mollick (2009), games have the capability of inducing experimentation that would otherwise be impossible.

Talking about the cognitive benefits of video games, Aguilera and Mendiz claim: “a number of studies indicate that games are conducive to the development of special skills like attention, spatial concentration, problem solving, decision-making, collaborative work, creativity and ICT skills” (2003, p. 8). Games have also been found to be conducive to deductive reasoning and hypothesis testing (Jenkins et al., 2003). Rieber et al. (1998), support that the use of games increases practical reasoning skills, motivational levels and retention. Finally, games have been found to push learners forward when facing problems, to support different learning styles and to be able to adjust to different skill levels (Jenkins, 2002). Therefore, they are designed to enable learners to take control of their own learning (Papert, 1998). Another argument in favour of games as learning machines is that due to their design (game settings are often situated in 2D or 3D space) they can help increase spatial development. Furthermore, the educational possibilities that games provide are similar to those of active learning, which allows learner participation in the learning process (Paras & Bizzocchi, 2005). This way, learners can engage with and to an extent create their own learning experiences via a process of reflexion. It is important to point out that learning is not only a cognitive but also an emotional process and games can offer pleasurable experiences and facilitate positive emotions that impact the learning process (Baker et al., 2010). Finally, the cognitive benefits of games as learning tools in comparison to traditional methods seem to be supported by recent literature (Wouters et al., 2009; Sitzmann, 2011; Ortiz et al., 2015), while according to (Vogel et al., 2006): “across people and situations, games and interactive simulations are more dominant for cognitive gain outcomes”.

Having looked at the above benefits of video games with regards to motivation, engagement and the learning opportunities they provide, it becomes obvious that game-based learning could become an interesting medium to facilitate learning. It is thus predicted that as game technologies evolve and player patterns change, more game-based frameworks will continue to develop, offering growing potential for learning. As games become more popular among various age groups and more accessible to a wider audience, as further discussed later in this chapter (see section 2.3.4 Casual Games), it is expected that more games for learning will continue to appear in the future.

2.3 Mobile Games

The previous section discussed literature on game-based learning. Here theory associated with mobile games will be presented to provide a basis for considering such games for their possible learning potential and also identifying key design values, which inform the next stages of this research. The discussion begins with a consideration of what a mobile game is and moves on to provide an inclusive characteristics-based definition of mobile games. Then a brief history of mobile games is presented, followed by an overview of mobile game genres. Finally, casual games are considered and discussed in the context of this research.

2.3.1 What is a Mobile Game?

From the early stages of this research it was important to define the term mobile game. By understanding what a game is in the context of game-based learning, one can easily frame the types of activities that could be considered as mobile games for learning purposes. The term is made up of the word ‘mobile’ and the word ‘game’; it was therefore crucial to look into the word game, before attempting to define a specific type, which is a mobile game. However, defining what a game really is, is not straightforward and has been a topic of discussion amongst various scholars over the past few years (Caillois, 1961; Juul, 2003; Crawford, 1984; Rollings & Adams,

2003; Salen & Zimmerman, 2003; Tavinor, 2009; Rogers, 2010; Elias et al., 2012; Waern, 2012 among others).

There appears to be no one single definition of ‘game’ in the literature, but rather a variety of definitions of what constitutes a game and what its main characteristics can be. To better define the term, some key definitions both from the computer games design as well as the game-based learning literature, will be provided here. An early definition came from Crawford (1984) who provided four common characteristics of games including representation (the closed formal system which subjectively represents a subset of reality), interaction, conflict, and safety (meaning the results/consequences of the game do not hold in reality). Rollings and Adams (2003) defined games as forms of participatory or interactive entertainment that take place in an artificial universe governed by rules. They also distinguished games from toys, which are objects one can play with without rules (Rollings and Adams, 2003, p. 35). Salen and Zimmerman defined a game as a: “a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome” (2003, p. 96). Oxland (2004) provided some characteristics of games and claimed they were made up of rules, boundaries, feedback, the game world interface, context sensitivity, goals, challenges, a game environment and balance. Talking about the nature of games, Fullerton (2008) came to the conclusion that a game is: “a close, formal system that engages players in structured conflict and resolves its uncertainty in an unequal outcome” (p. 43). A simple, yet inclusive definition comes from Rogers (2010) who claims that a game is an activity, which requires at least one player, has rules and a victory condition. A newer definition comes from Waern (2012) who claims that: “a game is a designed or emerging system of rules, goals and oppositions, which has as its primary purpose to allow people to engage with it for paratelic reasons, while agreeing that the actions performed are re-signified” (p. 11). Finally, Elias et al. (2012) attempted to develop a vocabulary for games by discussing their characteristics as general groups of features that provide descriptions of what the game is. They provided seven groups of characteristics each describing a specific aspect of games, with characteristics ranging from the number of players, to rules, outcomes and rewards, among others.

However, definitions have also been provided from the game-based learning research field, with one of the most useful being that of de Freitas (2006) who defines computer-based learning games as: “applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences” (p. 9). Another useful definition is that of Klopfer who defines a game as: “a purposeful, goal-oriented, rule-based activity that the players perceive as fun” (2008, p. 14). Useful in the context of game-based learning is also Prensky’s classification of the six structural elements of games, which include rules, goals and objectives, outcomes and feedback, challenge, interaction and representation or story (Prensky, 2001). Whitton (2010) also proposes ten characteristics that can be used to define a game-based learning activity, including competition, challenge, exploration, fantasy, goals, interaction, outcomes, people, rules and safety.

Looking at the above definitions it becomes obvious that there is no one single way of explicitly defining what constitutes a game and therefore a useful approach would be to utilise the key characteristics of games, shared amongst most definitions, to describe ‘game’ and ‘non-game’. It is argued that a characteristics-based approach, as suggested by de Freitas (2006), is probably the most useful in this context since it relates to game-based learning and is inclusive of a range of different game types and game-like applications. Whitton (2010) also supports the characteristics-based definition approach and argues that creating an absolute division of what a game is or is not, is artificial if not impossible. Talking about definitions, Elias et al. (2012), write: “There are no precise definitions of complex concepts like ‘game’, no definitions that will include all things that people accept as games and exclude all things that people reject”. For the purposes of this research it was therefore decided to examine common definitions of games and to compile a set of recurring characteristics to frame what a game is. Obviously not all activities will exhibit the exact same, or all of the characteristics, however the more an activity exhibits the more game-like it can be considered to be. The compiled list of game characteristics is presented in the following table:

Characteristic	Description
Rules	Artificial constraints that bind the gameplay and impose limits. They also assist in instructing the player how to play.
Goals	Explicit objectives that inform the player of the purpose and winning state of the game. They can be pre or player-defined.
Challenge	Existence of tasks/problems that require effort to be completed/solved. Types and degrees of challenge can vary.
Outcomes	The way of measuring the players achievements and progress towards game goals.
Interaction	Player actions influence the game state and evoke feedback, which in turn helps with deciding about the following actions.
Fiction	This is the representation of the game, which includes fantasy. It is the existence of a make-believe world, character or story.
Safety	Games allow for experimentation in a safe, consequence-free environment separate from the real world.
Engagement	Via flow, balance and mental stimulation, games facilitate player engagement.

Table 2-3: Characteristics of games

In various game definitions coming from the game design industry, entertainment and fun are also used as key characteristics, although they have not been included here. This is not due to lack of importance, since games aimed at learning should also be fun, however this is a characteristic that is individually interpreted by different people, and is thus subjective. It is therefore replaced here by engagement, which is not only key for games but also for learning. Arguably, games, either for entertainment or learning, should at least be engaging to players and draw their attention to in-game activities. Engagement can be achieved via design and observed and measured via different techniques. The above characteristics-based definition of games will be used throughout this research to help define what a game is and to allow an examination of those characteristics in the way they affect adult learning.

Having looked at the main characteristics of games, the next step is to look specifically at mobile games and attempt to define what they are. It is important to note however that due to the novelty of the field, definitions and terminologies related to mobile games are not yet clearly arranged, while each country and each game research institution has their own terminologies (Jeong & Kim, 2007). Simply put, a mobile game is one played on a mobile device.

There is however a narrower and broader scope for the definition, which has to do with the types of devices included. Mobile games can be narrowly regarded as games conducted through handheld devices with network functionality, where portability and networkability are the two key elements of the definition (Jeong & Kim, 2007). This definition is inclusive of mobile devices such as cell phones, smartphones, tablets and other devices with wireless networking functionality. It therefore differentiates such devices from other more traditional platforms, such as PCs and consoles, which may not feature portability and networkability at the same time. Up until 2008 (Unger & Novak, 2012), the definition excluded console style handheld gaming devices, which were primarily gameplay focused and did not include the element of networkability. With the advent of handheld consoles featuring networking capabilities however, as discussed in the next sub-section looking at the brief history of mobile games, the definition has become more inclusive of a number of different devices. Nowadays, the meaning of mobile is inclusive of both portability and network functionality and therefore a broader definition, which includes handheld game-dedicated consoles, can be used (Jeong & Kim, 2007).

For the purposes of this research however, it was felt important to narrow the scope of the definition, to include cell phones, smartphones and tablets and to exclude handheld gaming consoles. This was due to the nature of handheld gaming consoles, which are different from other mobile devices, since they are primarily focused in gaming activities (Bouca, 2012). Narrowing down the scope was also important to allow for a cleared focus, to inform design decisions and to limit ambiguity, which due to the novelty of the field, was already present with regards to the various concepts directly linked to the research. The narrower definition of mobile games is therefore adopted here. In this context, “mobile games are those played on non-traditional handheld consoles” (Unger & Novak, 2012, p.10), where handheld gaming consoles are considered traditional and excluded from the definition. In the context of this research therefore, non-traditional handheld consoles are considered those featuring portability and networkability (e.g. smartphones), while traditional are considered those primarily gameplay focused which did not originally include the element of networkability (e.g. Game Boy, N-Gage, Nintendo DS etc.). Finally, it is

worth mentioning that the differences between designing for the mobile and other platforms, such as PCs and consoles, are significant and that mobile game design has its own specific advantages and drawbacks (Scolastici & Nolte, 2013). Issues of mobile game design are further discussed in Chapter 5 (Developing Design Guidelines for mGBL). In the next sub-section a brief history of mobile games will be provided.

2.3.2 A Brief History of Mobile Games

Looking into the history of mobile games is an important step in defining and investigating them further. Mobile games are part of the broader field of electronic games and mobile entertainment (Parikka & Suominen, 2006). The history of mobile games is closely linked to the development of mobile devices. Although mobile devices were originally conceived in the late 1940s; however it was not until 1973 that the first call on a mobile ‘cellular’ phone took place in the United States (Unger & Novak, 2012, p.4). Until the early to mid-1980s, commercial cellular services were in place in various countries. This analogue first generation (1G) of mobile devices was later replaced by digital 2G, 3G and eventually 4G, each of which reflects a radical technological shift in the way information is transmitted to the device (Unger & Novak, 2012, p.8). The second generation (2G) of mobile phones, which were smaller in size in comparison to 1G, appeared in Europe in 1991 and introduced SMS messaging. It was in the late 1990s when mobile games first appeared on feature phones (Unger & Novak, 2012), which functioned predominately as phones with some extra capabilities and which pre-existed contemporary smartphones. One of the earliest and most successful mobile games was Snake, which was originally released in 1997 and came preinstalled on Nokia phones. Snake is one of the simplest yet most engaging games ever developed and in this original version it was black and white and featured a snake as the main character, which gradually grew until it could no longer fit on the screen and ran into itself. It was one year later in 1998 when colour mobile screens were introduced. Naturally, this was a major breakthrough for mobile gaming.

Increased technological advancements resulted in later device generations and led to the rise of the smartphone, a mobile device which functions not only as a communication device but also as a small computer. Ten years later in 2001, 3G was introduced. It was then that camera phones made an appearance and capabilities such as running applications and web browsing were enhanced. Camera phones brought a massive jump in memory and an increase in the screen size to handle photography, which also resulted in various web-based games making the jump to mobiles (Unger & Novak, 2012, p.12). A major breakthrough in the history of mobile devices was also the introduction of smartphones such as the Blackberry in 2003 and the iPhone in 2007. Currently 3G capabilities have been expanded and we are in the fourth generation (4G) of mobile systems, which was introduced in 2010. Contemporary devices have morphed into small computers with communication capabilities, featuring high resolution screens, responsive touch screens, powerful processors, Wi-Fi connectivity, image and video capture, voice recognition, storage capacity, GPS systems and so on. Due to their enhanced capabilities modern mobile devices have therefore emerged as powerful gaming platforms and are suitable for running game applications, with much fewer limitations in comparison to a few years back.

The history of mobile games is also closely linked to that of handheld games, which set foundations that were later adopted in mobile games design. Handheld gaming goes back to 1977, when Mattel released the game Football, which was playable on a handheld device with a simple display featuring an array of red LEDs (Klopfer, 2008, p. 34). This type of handheld device was single-use and was exclusively used for playing the specific sports game. Single-use keychain games such as Tamagotchi, which appeared in 1996 (Parikka & Suominen, 2006), or other popular virtual pet games have also proven massively popular in the past and are still represented in the market (Unger & Novak, 2012, p.20). The 1980s however were dominated by Nintendo's Game & Watch, which innovated in bringing arcade games like the Mario series to handheld devices and enabled the development of later handhelds like the Game Boy in 1989 and much later the Nintendo DS in 2004 (Klopfer, 2008, pp. 37-40). In 2003, Nokia N-Gage, the first cross-over between handheld and mobile was released (Parikka & Suominen, 2006).

The N-Gage was an attempt to combine the console gaming experience with phone capabilities, and though it was not as successful as anticipated it helped open the door between the mobile and handheld industries (Unger & Novak, 2012, p. 22). Nowadays the mobile game industry is rapidly growing, while the advent of smartphones coupled with constantly expanding capabilities and the emergence of app stores has turned mobile devices into powerful gaming platforms. Mobile phones and tablets today are the gaming console almost everyone has, which at the same time allow for communication and web access.

One major development, which was informed by the need for a better distribution model for smartphone applications, was the development of app stores. Nowadays various app stores exist and in most cases device manufacturers have their own digital distribution store, dedicated to device specific applications. However, it is worth noting the impact of the Apple App Store, which followed the release of the iPhone and was introduced in 2008 alongside the iOS software development kit (SDK) for the development of third party native applications with full access to the iPhone's capabilities. To date the Apple App Store is still one of the app distribution channels with the most third party apps and the one with the strictest review processes regarding the quality of the applications submitted for user distribution. Finally, a major development that has massively influenced mobile gaming is the advent and phenomenal success of mobile touchscreen tablets, with the iPad introduced in 2010. At the time of writing, the mobile gaming industry has truly taken off with gamers estimated increase reaching 835.7 million by the end of 2015 (Jefferson, 2010). On the same time, according to a recent study, games appear to be the most popular mobile applications (Nielsen, 2010). The popularity of mobile games is also supported by a more recent study, which revealed that in June 2015 games were the most popular category in the Apple App Store (Statista, 2015). Over the past couple of years, interest in mobile games has constantly increased to the point that for the first time game development optimisation was targeted in a mobile operating system, with the iOS 7 released in September 2013 featuring two new game specific features. The first was the integration of game controllers and the

second was a sprite animation and particle physics engine, natively mimicking external game engines' functionality.

Having defined mobile games and looked into their historical highlights, in the next sub-section the key characteristics of various mobile game genres are discussed.

2.3.3 Mobile Game Genres

Examining mobile game genres in order to consider which of these could potentially be more effective in the context of mobile game-based learning was a next important step for this research. Though the learning potential of different genres will be further discussed in Chapter 6 (Designing Mobile Game-based Learning), an initial analysis will be provided here. It is important to note however that similarly to the definition of games, a relative openness exists when it comes to explicitly framing genre characteristics, since there is no one single taxonomy of game genres. As the games industry grows and changes, the number of different types of games also grows and thus categorising games into specific genres becomes more challenging (Dahlskog et al., 2009). According to Oxland (2004), identifying what constitutes a genre is fraught with ambiguity since genres often tend to overlap, while certain games may fall into several categories. The difficulties of genre classifications, have also been discussed by Clarke, Lee and Clark (2015). It is understood that various genres and sub-genres featuring small differences have been identified in the literature; however there are also similarities between broader categorisations. It was therefore not considered helpful at this point to attempt to identify all possible types of games that exist but to provide a broader and therefore more manageable categorisation, by looking at the most common mobile game genres. The aim was to define their key characteristics in the context of platform specificity, which would later help to identify benefits and challenges with regards to applicability for learning and therefore guide the decision of a game genre to develop as the user evaluation instrument. The below categorisation is intended to put forward the idea that different types of mobile games exist and is in no way exhaustive.

The list of genres discussed below has been extracted from the literature (Crawford, 1984; Prensky, 2001; Rollings & Adams, 2003; Oxland, 2004; Apparley, 2006; Unger & Novak, 2012; Schell, 2014).

Adventure

Adventure games involve undertaking a series of actions, interacting with other characters, objects and/or the game environment to complete a quest or solve a mystery. A narrative often frames gameplay, though in mobile gaming this may be less extensive in comparison to adventure games playable on other platforms. Mobile adventure games are quite popular since the traditional point-and-click interface is a natural fit for mobile devices featuring touch control systems.

Examples:

Sword and Sworcery (Capybara Games Inc, 2011)

Minecraft Pocket Edition (Mojang, 2011)

The Simpsons: Tapped Out (EA, 2011)

Puzzle

Puzzle games involve problem solving and come in various forms that test skills such as logic, language, pattern recognition, etc. Puzzles are widely popular in mobile gaming since they are fit for context. Such games are often easy to pick up and play, provide a mental challenge and support mini-level architecture, which allows the player to engage for short periods of time, without preventing longer play sessions. Many of the most well known mobile games are puzzles.

Examples:

Angry Birds (Rovio Entertainment, 2009)

Bejeweled (PopCap, 2007)

Cut the Rope (ZeptoLab, 2010)

Action

Action games involve a physical challenge and often base gameplay around skills such as hand-eye coordination and reaction time. Popular sub-categories of action games for mobile are shooting games, fighting games and sport games. These games often involve the use of weapons to defeat enemies or simulate an activity. Though very popular, such games pose a design challenge for mobile devices, since they often require free directional control. Simplifying to a 2D camera however, coupled with gesture controls (e.g. tap to shoot/speed up) can work well on mobile.

Examples:

OMG Pirates! (Mika Mobile, 2012)

Zombievillage USA 2 (Mika Mobile, 2011)

Need for Speed Most Wanted (EA, 2012)

Strategy

Strategy games involve decision-making to achieve ingame goals. Strategic decision-making can be applicable to various contexts and examples of such games may include battle, resource management, world building, etc. Strategy games are another type that could be well represented in the mobile platform, although at the time fewer well-known titles exist in comparison to other types. Arguably, strategy games could be better suited to tablets due to their larger screen size, which allows space for additional information (e.g. resources, states, stats, etc.); however strategy games do not require massively complex navigation controls, which makes them suitable for the mobile devices (Unger & Novak, 2012, p. 94).

Examples:

Plants VS Zombies (PopCap, 2010)

Clash of Clans (Supercell, 2012)

Dinner Dash (Play First Inc, 2010)

Platformer

Platformers (or platform games), involve the movement of the character through a series of platforms, which constitute the game environment. The aim is to avoid obstacles and gather rewards (e.g. coins), until the end of the level is reached. Gameplay is often linked to a story, which frames the final aim (e.g. save the princess, find the treasure, etc.), although this is not necessary. Platformers work well on mobile devices utilising affordances such as the touch control systems and the fixed position cameras. Additionally, platform games are a good match for the mobile context since they are often playable with one hand, either via one button control or the accelerometer.

Examples:

Canabalt (Semi Secret Software, 2009)

Doodle Jump (Lima Sky, 2011)

Pizza Boy (Acne Production AB, 2012)

Role-playing

In these games the player takes on the role of a character within the game world. Role playing games (RPGs) can be both single-player and multi-player and usually involve an elaborate story. Simple point-and-click systems are often enough for controlling RPGs, making them a good fit for mobile interfaces. However, the genre is still not as popular on mobiles in comparison to others mentioned here. Shorter play sessions and interruptibility can be a limitation for complex narrative development, however there is interesting scope for applicability, especially for tablets.

Examples:

Ash (SRRN Games, 2010)

Vay (SoMoGa, 2008)

Final Fantasy (SQUARE ENIX, 2010)

The above list is intended to provide a summary of the most common types of mobile games and to consider the most distinctive characteristics of each type. It is possible however that a single game may fall into more than one category. The above game genres are revisited in Chapter 6 (Designing Mobile Game-based Learning) and used as a guide for thinking about the types of games that may be suitable for different learning applications. In addition, an understanding of mobile game genres was important to inform the decision about the type of game prototype to be developed as part of this research.

In the next sub-section casual games will be discussed. Casual design values as well as casual player audiences will be considered in the context of mobile games for learning.

2.3.4 Casual Games

Having looked at the different types of mobile game genres, the next important step was to consider casual gaming and to discuss the term casual in the context of this research. Casual games are not necessarily a genre in themselves since they come in many different types (Whitton, 2010) and thus are not included in the classification made above. However, since mobile phones seem to be the perfect casual gaming platform (Klopfer, 2008), mobile games are often associated with casual gaming. Additionally, mobile games are considered to generally aim towards a casual audience (Unger & Novak, 2012, p. 30).

Casual games could be described as: “games that generally involve less complicated game controls and overall complexity in terms of gameplay or investment required to get through the game” (Wallace & Robbins, 2006). The International Game Developers Association (IGDA) defines casual games as: “games with a low barrier to entry that can be enjoyed in short increments” (IGDA Casual Games White Paper, 2008, p. 9). Although casual games have various distinctive characteristics the common denominator is their accessibility, meaning the low barrier to entry for the mass consumer (IGDA Casual Games White Paper, 2008). It therefore becomes

apparent that casual games can be played for a few minutes and easily stopped and restarted and are therefore designed for short bursts of play, which translates to many small levels that follow the same play pattern (Whitton, 2010).

Casual games are quite diverse in terms of gameplay types and distribution channels and they can be played on desktops, mobiles, consoles, web browsers, etc. Though casual games had been linked to web gaming for a while, there is a gradual move away from the web-based PC to other platforms and nowadays, mobile gaming has already been labelled as casual gaming (Tams, 2006). A casual game can be a puzzle, word, action, card game, etc. (Wallace & Robbins, 2006), depending on design and mechanics. Juul argues that the two most common types of casual games are “mimetic interfaces” where the player’s physical activity mimics the game character’s activity on the screen (e.g. Nintendo Wii, Guitar Hero, etc.) and “downloadables” that are purchased online or from various app stores and are downloaded to the player’s device to be played in short intervals of time (Juul, 2009). Mobile games in particular fall into the second type, since they are downloaded directly to the user’s device.

If we were to summarise the main characteristics of casual games we would have to begin from user friendliness or the user’s ability to “pick up and play” (Juul, 2009), which is also one of the main reasons that make casual games popular amongst a wide variety of audiences. From game mechanics to content and theme, casual games are designed to entertain and engage the casual player. Casual games usually feature a small set of mechanics and one core mechanic, while still being sufficiently deep and allowing for player exploration and performance (Nealen et al., 2011). Game mechanics have been defined by Jarvinen as: "means to guide the player into particular behaviour by constraining the space of possible plans to attain goals" (2008, p. 254). Sicart (2008) on the other hand, defines mechanics as methods invoked by agents, which are designed for interaction with the game state. Examples of game mechanics could include actions that players can take in the game world, which are constrained by rules such as: ‘climb’, ‘collect’, ‘jump’, ‘shoot’ etc.

Core mechanics refer to repeated means with which the player can interact with game elements, while attempting to influence the game state towards a goal (Jarvinen, 2008). In more casual settings, core mechanics can be directly applied to solving challenges that lead to the desired end state (Jarvinen, 2008), as is the case in many casual mobile games. Furthermore, casual games tend to feature only a few, simple controls that integrate with the mechanics (Sicart, 2008). This is because in a casual setting the structure of mechanics and thereby how they map to controls, is simplified (Sicart, 2008). Simple controls and usable interfaces make casual games accessible to novice players and contribute to the player's easy entry into play (Trefry, 2010). Learnability is also another characteristic of casual game design, assisted by the fact that in games like 'Angry Birds' and 'Plants VS Zombies' the core mechanic helps players learn how to play the game as they go along (see sections 5.2.1 Angry Birds and 5.2.2 Plants VS Zombies).

In conjunction with intuitive interfaces, gameplay often features clear rules and objectives (IGDA, 2009), positive feedback, a gradually increasing level of difficulty and high responsiveness. Important is also the flexibility casual games provide which allows gameplay to fit around people's daily lives in comparison to other hardcore games, which usually require a lot from the player before starting to play (e.g. dedicated hardware, advanced skills, knowledge of genre conventions, long hours, etc.) (Juul, 2009). In the mobile context interruptibility is important and casual games can facilitate it since according to Juul (2009), casual game design allows the players to enter and leave a game very quickly, making it possible to play while at work, or while waiting for a phone call. Additionally, casual games are designed to be playable in short bursts rather than for prolonged sessions (Whitton, 2010), which makes them ideal for playing during downtimes, not requiring a massive time commitment to progress in the game. And finally, casual games tend to be positive and rewarding since gameplay often emphasises mechanics such as nurturing, building, collecting and collaborating (Kultima et al., 2009). Additionally, gameplay is often based on reward systems which when coupled with high responsiveness are described as "juiciness" and is what makes players feel in control, coaching them through the game and letting them know how they are doing (Gabler et al., 2005).

Reward cycles and positive feedback however do not account for too easy and non-challenging games; contrary to the stereotype, many players of casual games enjoy difficult games (Juul, 2009, p. 40). It is therefore argued that these key characteristics of casual games, which have contributed to their popularity among diverse audiences, do not make them less challenging. Additionally, quite interesting is the fact that the design characteristics of casual games as previously described, align to general mobile game design characteristics discussed later in this thesis (see Chapter 5: Developing Design Guidelines for mGBL).

Jasper Juul talks about the emergence of casual games as a breakthrough moment in the history of video games, where for the first time gameplay moves from complexity towards simplicity, while new flexible designs allow it to fit into people's daily lives (Juul, 2009). The appeal of casual games is such that in 2007 the casual industry was a \$2.25 billion industry, growing by 20% each year (Tams, 2007). More recent studies show a dramatic rise in the global market and reveal that in 2013 the casual games industry was a \$75.5 billion industry with a projection to reach \$102.9 billion by 2017 (Casual Games Association, 2014). In the past few years, casual games have appeared as a major trend in the video games industry and have eclipsed the stereotype of shooting games and the male teenage player, reintroducing games as accessible for all audiences (Chiapello, 2013).

The combination of accessibility, flexibility and positivity, the three key characteristics of casual gameplay, provide beneficial affordances for mobile game-based learning addressing a diverse adult audience. The design values embedded in casual games reflect a casual way of play and are of particular interest when attempting to design games for a broader audience, beyond the traditional hardcore gamer. Considering contemporary video games, one can easily realise how complex and hard to use they have gradually become. Many games feature extended stories, difficult gameplay and complex mechanics that often require a prior knowledge of genre conventions and demand an unrealistic time commitment for adults with other, everyday responsibilities (professional, academic, personal, etc.). With the casual turn towards simplicity and flexibility however, especially coupled with the

emergence of mobile platforms, gamer profiles move away from the stereotypical teenage boy to a wider demographic. Furthermore, traditional hardcore games are often technically too complex to run on mobile devices, and even though devices have become more and more powerful, they still provide limited opportunities to accommodate hardcore gameplay. As time passes and technology progresses it is predicted that more hardcore games will make it to mobile, however it is argued that core gameplay is still not as suitable for a mobile context. The affordance therefore becomes apparent and is informed by user needs, device circumstances of usage, gameplay patterns and technological capabilities. Mobile games for learning, targeted to appeal to a wide audience, should be designed with accessibility and usability in mind and should base gameplay around simple mechanics, shorter play sessions and an overall pick up and play philosophy. They should therefore be designed to appeal to a casual audience. At the same time, mobile games for learning should foster flexibility. Flexibility is what distinguishes casual games from traditional hardcore games (Juul, 2009). Allowing adults flexible play by ensuring gameplay fits around busy schedules and changing life stages, minimises their barriers to entry.

The term casual can be categorised in respect to game type, player type or playing attitude (Kultima, 2009). However, Kultima et al. argue that: "Casual is not a simple list of properties of a game. The phenomenon is an answer to a specific transformation of game cultures, forming a set of design values that correspond to these changes" (Kultima et al., 2009, p. 5). The previously mentioned casual design values therefore correspond to transforming gaming cultures informed by player types and attitudes. It is therefore important to examine the characteristics of the casual player to understand attitudes towards play. The casual player can be anyone, and the term may refer to any user who can easily pick up a game and play without great effort even if he/she does not usually play computer games (Millis & Robbins, 2005). According to IGDA, the most populated demographic for casual games is between the ages of 30-45 years old (IGDA Casual Games White Paper, 2008, p. 9), while a more recent study by the Casual Games Association (CGA) revealed that the most powerful demographic for casual games played on mobile devices is between

the ages of 25-34 years old (Casual Games Association, 2012). The Casual Games White Paper summarises the general characteristics of casual gamers as follows:

- They enjoy simple to learn games with basic controls.
- They like quickly accessible games with no/minimal setup.
- They enjoy the fact that games can be consumed in small increments.
- They play to relax, pass time, socialise and achieve certain goals.
- They do not perceive themselves as gamers.
- They generally do not play violent games.
- They don't spend money on game hardware or peripherals.

(IGDA Casual Games White Paper, 2008, p. 15)

Casual games therefore appeal to both male and female audiences of all ages who play games with gentle learning curves that do not require massive involvement, in comparison to hardcore gamers who play games that do require significant involvement and are usually quite complex and competitive (Wallace & Robbins, 2006). Juul contrasts the stereotypical casual and hardcore player in further detail. According to him the casual player: “has a preference for positive and pleasant fiction, has played few video games, is willing to commit small amounts of time and resources towards playing video games and dislikes difficult games”, while the hardcore player: “has a preference for emotionally negative fiction, has played a large number of video games, will invest large amounts of time and resources towards playing video games and enjoys difficult games” (Juul, 2009). Explicit distinctions of player types however may not necessarily reveal a playing behaviour; we cannot judge game experiences by rigid criteria (Kultima, 2009). Although casual games have been designed to be playable in short, few-minute sessions for example, casual players will often play for longer periods of time and maybe even several hours. Loren Hillberg, executive vice president of Macrovision, states that surveys examining the playing habits of casual gamers “determine that mainstream audiences dedicate a substantial amount of time to gameplay and not just the 15-minute increments as previously thought” (Macrovision Corporation, 2006).

It is therefore important to realise that player types are not mutually exclusive and they represent general tendencies towards playing habits. It is also interesting to note that often, casual players do not consider themselves as gamers (Twist, 2005), even though they may play long hours during the day. On the other hand, it is often the case that former hardcore gamers are now playing games casually since they may not have the same amount of free time they used to have due to other commitments (Cybulskie, 2004). In the context of mobile gaming however, the most popular games on the mobile platform are meant for the casual gamer (IGDA, 2005). A good percentage of mobile players aren't gamers in the classic sense but fall into the more general umbrella of casual games (Unger & Novak, 2012). This explains the wider demographic of mobile gamers, which is inclusive of both male and female players as well as a variety of age groups and is more representative of an adult population. With mobile's casual play of short play sessions and ease of use coupled with ubiquitous availability, people who might not have considered games as a pastime before are now trying out all kinds of game experiences (Unger & Novak, 2012). In the context of mobile game-based learning targeted at adult learners, openness is of significant importance, since learning games can be designed to address and reach larger and more diverse audiences.

Mobile and casual gaming are currently closely interlinked. This is not however to say that all mobile games are casual. Attempts to bring hardcore games to the mobile platform have already taken place, while as device capabilities keep evolving it is predicted that hardcore games will become widely available as well. The suitability of the mobile platform for casual gaming however has to do with context and playing attitudes. While it is true that the demographic of mobile device users (thus potential mobile players) is different from computer and console game players (Unger & Novak, 2012), mobile gamers represent a class in themselves (Unger & Novak, 2012, p.102). They come with a certain mindset; they become mobile gamers once they start playing a game on a mobile device. Even hardcore gamers approach mobile games differently from how they would games on other devices, since in the situations in which they play such games their mindsets and expectations are different (Unger & Novak, 2012, p.103).

The way in which they use their mobile devices (e.g. smartphones, tablets) for entertainment differs from how they use console systems, computers or even handhelds. Mobile devices at the same time seem to be getting more popular since 44% of households in the UK own an iPhone, while 21% of 6-64 year olds play on smartphones and 18% on tablets (UKIE, 2016). User numbers keep growing, with most mobile gamers aged between 20-35 years old (Casual Games Association, 2013). Finally, the global mobile games market is currently increasing 23% yearly, expected to reach \$44B in 2018 (Newzoo, 2015). Furthermore, it is important to consider that mobile devices have unique interfaces (e.g. touch screens, accelerometers, smaller screen sizes etc.), which require new conventions to be followed, while also providing new gameplay possibilities (Unger & Novak, 2012). The mobile games audience however appears unified regarding expectations, informed by device circumstances of use and play patterns, which appear closer to casual values. To facilitate meaningful experiences in this context, games should favour notions of simplicity and accessibility (Kultima, 2009), while the importance of principles such as usability in design become more prominent in mobile games (Unger & Novak, 2012).

In this chapter thus far, literature on learning via mobile devices, game-based learning and mobile games has been discussed. In the following section theory will be drawn together to form the mobile game-based learning framework proposed.

2.4 Mobile Game-based Learning

The previous sections of this chapter looked into literature on three main areas of consideration including theories of learning which support adults developing their skills independently in a mobile context, game-based learning and mobile games. Here, these are drawn together to provide the theoretical foundation for the proposed framework of mobile game-based learning. In this last section of the chapter, the rationale for using mobile games for the learning of adults is summarised and presented. As stated earlier however, it is important to note that the mobile learning field is still relatively immature (Park, 2011) and that mobile game-based learning is

an area in development new to academic study. No one theory of mobile game-based learning exists, therefore demanding the development of new learning frameworks focusing on different aspects of application and design.

The introduction of the framework begins with a background consideration. The growing interest in the field of mobile learning is attributed to the increased viability of mobile technologies as learning tools due to their growing sophistication and affordability (Naismith et al., 2004). With mobile learning however, traditional instructional methods can no longer be exclusively used and new thinking must be incorporated in order for learning goals to be achieved (Ally, 2005). It is important to also understand that contemporary adults in general have a close relation to technology and games (Prensky, 2001), which they use in their daily lives, while the adoption rate of mobile devices over the past few years has been rapid. Attempting to therefore adjust e-learning approaches to a mobile context is not sufficient. On the contrary, mobile learning frameworks need to remain flexible and accessible but also engage learners in effective ways and thus game-based learning could be utilised in that direction. This is why it is argued here that mobile learning approaches targeted at adults should be extended to include games. Furthermore, research looking into the use of mobile technologies and games for learning (Trifonova, 2003; Naismith et al., 2004; Klopfer, 2008; Whitton, 2010; Perrotta et al., 2013), tends to focus on formal education or blended learning, often discussing teacher-led, context-aware or collaborative approaches (e.g. Klopfer & Squire, 2004; Facer et al., 2004; Huizenga et al., 2009; Zender et al., 2014; Tlili et al., 2015), while most of it is targeted at child learners. Less work has thus been done on using mobile games independently in informal settings, as personal learning environments able to support the development of skills in adults, especially where games are the overarching learning strategy instead of the tool for content delivery.

The game-based learning framework proposed here targets adult learners and considers their specific needs. It is also mobile since learning can take place anywhere and at anytime the learner chooses, mediated via a mobile device. It is therefore independent and informal in that it is learner-directed and can take place

outside formal learning environments. At the same time learning is intentional on the part of the learner, who understands that the activity undertaken will lead to learning. Learning in this context is considered lifelong since it is on-going, voluntary and self-motivated, while it is mediated by a game where learning goals are aligned to gameplay goals. This framework is informed by the needs of contemporary adults living in a mobile society and aims to advance a suitable intervention to support their independent skill development and self-training in an effective and engaging way. It is also informed by mobile technology usage patterns, as well as the recent growing popularity of mobile games for a diverse audience. It is therefore developed under the assumption that mobile gaming, which is already widely used for entertainment purposes, could potentially account for a powerful intervention that is able to support effective and engaging learning.

One of the main strengths of the framework is that it inherits and thus combines the benefits of mobile learning in terms of flexibility, game-based learning with regards to player engagement and mobile games in relation to accessibility and audience appeal.

$$\text{Mobile Learning}^{(\text{flexibility})} + \text{GBL}^{(\text{engagement})} + \text{Mobile Games}^{(\text{accessibility})} = \text{mGBL}$$

Mobile game-based learning (mGBL) addresses mobile content consumers and presents some key affordances for independent learning happening in an “anytime, anywhere” context (Geddes, 2004). One of the most important such affordances is the opportunity it provides for flexible, individualised learning that happens via short and frequent play sessions. This affordance is particularly important for skill development, training and review purposes. It also addresses adults’ increased barriers to entry due to life commitments, by allowing them to fit their training around their daily life. In this context, accessibility becomes key and thus informal learning should be supported. At the same time, individually owned devices provide opportunities for mobile game-based learning that is personalised, adapting learning content to the individual player (Agha & Ayse, 2011).

Interestingly, using mobile devices seems to appeal to both the tech-savvy as well as those not otherwise overly familiar with technology. This is accounted to a feeling of safety caused by a universal feeling of familiarity with using mobile devices and accessing content on the go, thus reducing any negative perceptions often experienced with technology-enhanced educational solutions (Jones et al., 2007). Research further shows that phones are the favourite learning delivery platforms in comparison to other devices (Mitchell & Cisic, 2006). An additional affordance of the proposed framework is its potential for retaining engagement, which increases the likelihood not only for acquiring knowledge but also transferring it to real life settings. Finally, mobile game-based learning is a suitable platform for microlearning, where short modules in the form of short bursts of play can be accessed on the go and fill gaps in user attention, during breaks from daily life (Trifonova, 2003). Microlearning as a theory of learning is well suited to mobile delivery since it is the most typical form of anytime-anywhere learning (Hug et al., 2006). This is because microlearning activities rely on access to learning resources that may happen during breaks in the learner's life and thus may take place in various locations and times throughout the day (Hug et al., 2006). Furthermore microlearning is well suited to informal learning settings, where learning becomes opportunistic and under the control of the learner. At the same time, informal learning is typically based on task specific activities where learners access specific pieces of information rather than a complete body of work, in order to support the acquisition of a certain skill (Hug et al., 2006). It thus becomes a natural fit for microlearning activities targeted at adults developing their skills independently.

Having established the basic principles of the mobile game-based learning framework proposed here, it is important to note that the medium of delivery is the mobile game and specifically the casual mobile game. As previously discussed in this chapter (see section 2.3.4) games that belong to any game genre could be casual games (e.g. casual puzzle, casual adventure, etc.), while casual games are associated with the mobile platform (Klopfer, 2008) and are often targeted towards a casual audience (Unger & Novak, 2012). The reason casual games are well suited to the mobile context is that their key characteristics match those of mobile content

delivery and consumption. Casual games involve less complexity in terms of gameplay or investment required to get through the game (Wallace & Robbins, 2006), while they are designed for accessibility and have low barriers to entry (IGDA Casual Games White Paper, 2008). At the same time, they foster flexibility, which distinguishes them from traditional hardcore games (Juul, 2009), by allowing players to fit gameplay around their busy schedules. These characteristics of casual games make them appealing to a casual audience, meaning a wider and more diverse population not necessarily otherwise engaged in game playing, which is more representative of an adult population. This is of particular interest in the context of mobile game-based learning, since in comparison with other types of game-based learning frameworks casual mobile games have the potential to appeal to a wider audience of learners.

At the same time, mobile casual games are suitable for microlearning delivery. Casual games are designed to be enjoyed in short increments (IGDA Casual Games White Paper, 2008), thus they can seamlessly deliver microlearning content via short and frequent bursts of play. Furthermore casual games' architecture is based on small levels that follow the same play pattern (Whitton, 2010), which could be translated to short, interactive mini-lessons that learners could take on the go. By therefore aligning game goals to learning goals, a mobile casual game could become a tool for learning that could allow learners to take control of their training, flexibly fitting it around their daily lives and having some fun while doing so, which could assist replayability and retention. This way, mini-puzzle games for instance could be designed to facilitate learning activities happening through micro steps in digital media environments, organising chunks of information in short and recurring time spans. According to Hug (2005), mobile game-based learning by multiple-choice exercises for example, is a concept of microlearning. Game mechanics (Jarvinen 2008; Sicart, 2008) such as the gradual addition of complexity layers and adapting difficulty and pacing, could then be built into the system to add didactic value to learning objects. In a mGBL context, microlearning could be enhanced by spaced repetition techniques (Baddeley, 1997), where small units of content are often repeated via spaced reminders to assist the recall of information.

This is particularly important in cases when content is presented over time (Godwin-Jones, 2010) and repeated, such as vocabulary acquisition for second language learning, the retention of facts and the summarisation of training content. Mobile delivery also allows for push notification integration, which could support spaced learning via reminders of learning content also acting as play motivators, inviting learners to return to the game for another short play session.

The proposed mobile game-based learning framework therefore addresses adults developing their skills independently, while its potential is rooted in the combination of mobile technology and casual games for the delivery of microlearning content in informal settings. The focus is on skill development and more specifically, here the particular case of mGBL targets English vocabulary development for second language learners (see Chapter 6 – Designing Mobile Game-Based Learning). Skill development for adults is a lifelong process and is in general targeted at building skills to add value to one's personal and career development. It becomes obvious however that the framework proposed here is applicable to a number of subjects and can support different learning goals. Mobile games could be designed to support a variety of learning objectives, each of which could be best supported by the use of a specific learning approach, which should be decided by case. Learning approaches rooted in existing educational theories such as behaviourism, constructivism, etc. are directly applicable to mobile learning frameworks as proposed by Naismith et al. (2004). It is not suggested however that mobile game-based learning is suitable for all kinds of learning, since not all kinds of activities and learning content are appropriate for mobile devices (Keegan, 2001). Here the proposed framework is based on a behaviourist approach to learning (see section 6.3.3 Language Learning Theory), which was considered suitable for mobile game-based microlearning for vocabulary development, which is the learning objective selected for the evaluation game prototype developed for this study. In this context, mini-puzzle games were developed to support a behaviourist approach to learning, based on cycles of drill and practice facilitating repetition and reward (Sharples et al., 2013). Finally, it is important to note that the proposed framework is not suggested as a replacement for

formal adult education but rather as an extension, or as an independent training solution for the development of skills in an independent, informal context.

Theory development is based on the mobile game-based learning framework discussed above, and underpins the design of a game prototype developed as part of this research, described later in this thesis (Chapter 6 – Designing Mobile Game-Based Learning). Arguing that research on mGBL should be based on both theory and practice, a design-led approach was adopted and a mobile game prototype created as proof of concept to assist hypotheses testing and user evaluation. The design of this prototype was informed by design guidelines for effective and engaging mobile learning games, which were synthesised and are presented later in this thesis (Chapter 5 – Developing Design Guidelines for mGBL). To be effective, such guidelines have been underpinned by the theories of learning previously discussed in this chapter and address the mobile context in terms of usability (Gu, Gu & Lafferty, 2011). The approach taken was therefore the one proposed by Herrington, Herrington and Mantei (2009), who recommend a design-led approach to mobile learning, with an eye towards improving the learning experience rather than focusing on creating principles which prove one theoretical approach over another. It is additionally informed by Reigeluth (1999), who argues that learning design models should be based on identifying the situations available and determining how to apply them in such a way as to address the desired outcomes in the learning environment. Although the case selected for the learning outcomes of the developed prototype is vocabulary learning, this study is not focused on a particular field but rather on principles of learning design applicable to mobile games able to support a variety of learning outcomes, which are targeted at adults learning independently.

In this chapter the theories, which provide the background for the rest of the research, have been presented. Literature related to games and learning in a mobile context has been reviewed and theory has been drawn together to form the mobile game-based learning framework proposed above and to provide a rationale for the use of mobile games for adult learning.

To further contextualise the theory presented in this chapter, which underpins the mobile game-based learning framework and supports the arguments made, the following diagram has been created to illustrate theory along with technology development. Major technological developments as well as major mobile game releases which have influenced this research, are therefore presented along with theory development, focusing around the timeframe of the research activities which took place. It is however important to highlight that although a specific operating system, device and development methodology have been chosen for practical reasons discussed on Chapter 6 (section 6.3.4 Technology), the proposed mobile game-based learning framework as well as the design guidelines developed in this research are not device specific. They therefore can be used to inform the design of any mobile game-based learning application targeted to adults developing their skills independently.

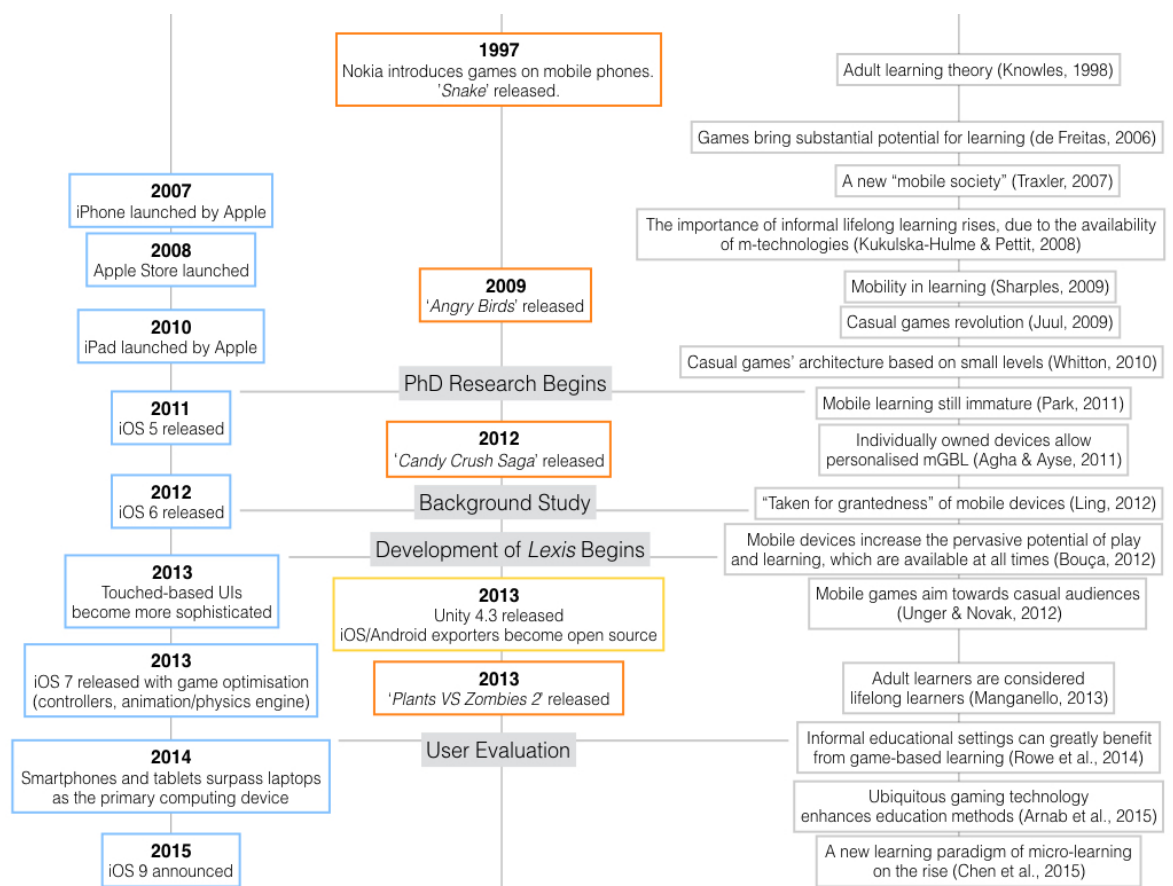


Figure 1-2: Key theory of the mGBL framework presented along technology development

The following chapter discusses the research design and methodological approaches taken for the work described in this thesis. It looks into research stages and data collection methods as well as research limitations and ethical considerations.

Chapter 3

Methodology

As a research domain, mobile game-based learning draws heavily on theory but is also strongly rooted in practice since it concerns the design, development and evaluation of mobile gaming technology. When investigating mobile game-based learning therefore, it is important to focus on both its theoretical and practical aspects. This chapter discusses the rationale for the research methodology as well as the ethical considerations and limitations that arose during the research.

3.1 Research Approach

An overarching influence for the research design has been the belief that although there is no one single approach to researching game-based learning, any such attempt should be carried out with integrity, recognising any limitations and potential biases. The research described in this thesis is grounded in both learning and design studies and a mixed methodology, originating from both quantitative and qualitative approaches has been adopted. To that end, both relativist and positivist philosophical influences have informed the study. Relativism is often associated with qualitative research methods, adopting the view that there is not a single truth and no external reality independent from human consciousness, since people attach different sets of meanings to the world (Robson, 2002). Positivism on the other hand, is usually associated with quantitative research methods, and views the world independent from peoples' perceptions of it, while experiences can be described in terms of objective facts hypotheses can be tested against (Robson, 2002). These two contrasting approaches have been here combined following Pring's (2004) view according to which dualism is false, since to visualise reality when undertaking research with humans, neither approach is suitable on its own. Data examined throughout this research therefore have been both qualitative and quantitative, while

corresponding research methods ranging from interviews to questionnaires have been used to collect them.

A mixed methods research design is useful to capture the best of both quantitative and qualitative approaches, since the researcher may want to both attempt to generalise findings and to develop a detailed view of the meaning of a phenomenon or concept for individuals (Creswell, 2003). In this research therefore inquiry begun by exploring the variables to study and surveying a large number of individuals, following up with a smaller number of individuals conducting more in-depth evaluations on a given intervention, in order to examine their experiences with it. In this context, gathering both quantitative and qualitative data was advantageous to better understanding research problems.

The first viewpoint that has informed the study is that the nature of research involving humans, either socially or educationally grounded, is individually constructed and thus subjective. Data collected and analysed therefore reflect that, by focusing on individual perceptions and attitudes towards experiences. The other viewpoint is that research is influenced on both the research design and the interpretation of results, by the beliefs and values of the researcher, and thus the researcher has a duty to recognise that and take it into account.

A considerable part of this research however is also practice-based and rooted on design, which includes developing concepts in stages and through various processes. The practise-based approach adopted for this research is influenced by the belief that knowledge requires experience (Kolb, 1983). Knowledge and experience are arguably closely related and a design-based approach carries these convictions into both research and practice. Design approaches from a holistic perspective applied in Human Computer Interaction can be concerned with a wider perspective in design or a broader understanding of the experiences it enables. Dourish (2004) talks about design as one that sees interaction within a larger frame recognising that an interactive artefact must be designed as part of this larger system. This is well applicable to practice-based, game-based learning where an interactive system can be designed as part of a larger frame relevant to knowledge. Furthermore Forlizzi and

Battarbee (2004) stress the importance of holistic factors of user experience going beyond usability. In the context of this thesis therefore, research design has been influenced by an experience design approach, as the methodology where the designer is focused on the overall experience of the end-user.

3.2 Research Phases

As previously mentioned in this thesis, mobile game-based learning is an area new to academic research and thus literature is still developing. At the moment, not a lot of established theory exists to support the potential of mobile games for the independent learning of adults and thus this research was aimed at progressing the discussion forward and producing relevant theory. It was therefore important to investigate both the potential benefits of mobile games to be used in contexts where adults build their skills independently, as well as to produce theory on best design practices for such games. As well as focusing on theory however, one of the main aims of this research was the design, development and evaluation of a mobile game, which could support skill building in adults. To meet these study objectives, the investigation was structured in three phases for each of which distinctive methods and techniques were used. The three phases were theory development, prototype development and evaluation.

The research draws on both qualitative and quantitative data collection methods and analyses. This is due to the fact that no one paradigm was considered to suit the purposes of the study wholly and therefore a mixed-methods approach was adopted. Qualitative study approaches are traditionally used to explore under-researched areas where more supporting theory is required (Creswell, 1994). In such case the researcher attempts to synthesise patterns or theory about phenomena or behaviours under investigation, using inductive reasoning and interacting with research participants. In the case of this research, qualitative methods for data collection were used for the final user evaluation and included interviews and think-aloud protocols, among others. Quantitative study approaches on the other hand, tend to be used when

a richer body of research supports the areas of investigation. Here, the aim for using quantitative methods was to analyse data and generalise them in order to gain understanding and make explanations. Following, the methods used for each of the three phases of this research are being discussed in more detail.

3.2.1 Theory Development

The first phase of this study focused on establishing a theoretical basis for mobile game-based learning and considered the reasons and possible benefits of using mobile games to support the development of skills in adults. The theory development phase was further divided in two stages. The first stage investigated the potential of mobile game-based learning and provided a rationale for using mobile games to support the learning of adults. The second stage focused on the development of design guidelines for effective, usable and engaging mobile learning games.

For the first stage of theory development, two data collection methods were adopted including a literature review and a background study in the form of a large-scale online survey. This initial stage of the research provided insight into the attitudes of adults towards learning with a mobile game and influenced the design of the game prototype developed in the next phase of the research.

Literature Review

Theory development was informed by existing literature. The purpose of the literature review in a research study is to share with the reader the results of other studies that are closely related to the study being reported and to relate the study to the larger on-going dialogue about a topic, extending prior studies (Creswell, 1994). This way the scope of the inquiry is limited and the importance of the study is established. An initial review of the literature on learning and games was thus conducted at the early stages of this research. Literature reviews on other areas of interest were also conducted and provided the theoretical background for the rest of the study. Theoretical influences included literature on learning via mobile devices, game-based learning and mobile game design.

Background Study

A background study was conducted to evaluate the potential of mobile games as learning tools for adults and to provide evidence on adults' perceptions and their views on the acceptability of game-based learning. An online survey was therefore designed and conducted amongst four hundred and three (403) participants. Web-based surveys operate by inviting prospective respondents to visit a website where the questionnaire can be found and complete it online (Bryman, 2004). The survey examined participants' attitudes towards the use of mobile devices, mobile gaming in general and the suitability of mobile games as learning environments.

More details on these two methods employed for data collection, can be found in other chapters of this thesis. Chapter 2 (Literature Review) discusses theory, which supports the use of mobile game-based learning for adults, while Chapter 4 (Background Study) describes the development, data collection and analysis as well as the outcomes of the online survey.

Having established a rationale for the use of mobile games for learning it was then important to consider how such games could be best designed to be effective and usable. A key motivation driving this research was to guide the design of mobile games able to support skills development in adults in an informal, lifelong context. To that end, a set of guidelines had to be developed to aid the creation of mobile learning games for the specific audience. The developed guidelines were grouped in four sets so as to be readily usable in terms of ease of use, and coherence. The development of these design guidelines constituted the second stage of the theory development phase.

For the second stage of theory development, two data collection methods were employed including a review of existing theory as well as a case studies review. This stage of the research determined good practices for the design of mobile learning games for adults. Design guidelines were developed by synthesising findings from

secondary research in the form of existing theory content analysis, along with findings from primary research in the form of a case studies review.

These guidelines were later applied to the development of a game prototype created as part of the research, to inform the direction of design for effective mobile game-based learning.

Review of Existing Theory

Design guidelines were informed by theory on the areas of learning design, engaging game-based learning, mobile usability and game design. Guidelines were then synthesised from existing design strategies extracted from the review of previous work in the above areas. To gather data on existing design strategies, a review of extant theory was conducted, during which scrutiny of relevant literature took place. The final strategies developed were used to inform the design of a working game prototype for the next phase of this research.

Case Studies Review

To extend the extant theory review, primary research in the form of case studies review was also conducted and it informed the development of the design guidelines. A case study is an implementation of a research method involving up-close examination of a subject of study (Yin, 2004). Eight (8) popular mobile games were selected and reviewed with regards to their gameplay and interface to extract good design practises. Data extracted then allowed the generation of ideas on engaging design and later informed the design of the game prototype that was developed for the next phase of this research.

Further details on the design guidelines as well as the case studies review can be found in Chapter 5 (Developing Design Guidelines for mGBL).

3.2.2 Prototype Development

To examine the applicability of the design guidelines synthesised, during the second stage of the theory development phase as described above, to the design and development of an actual mobile learning game, it was decided to build such an application from the ground up. This decision was also supported by the lack of literature on mobile game-based learning frameworks proposing helpful guidelines on how to develop an effective, engaging and useful mobile learning game for adults learning independently. At the same time, the development and testing of a ‘proof of concept’ application would allow the generation and collection of empirical data. Before progressing on to developing the game prototype however, it was important to decide the domain it would fall under. Language learning was finally selected as an appropriate domain and this decision was informed by both the background study survey conducted during the first stage of the theory development phase as discussed in Chapter 4 (Background Study), and also an investigation on types of games and areas of learning suitable for mobile delivery, as described in Chapter 6 (Designing Mobile Game-based Learning). The game prototype developed was aimed at assisting non-native speakers of English build their English academic vocabulary skills and it was a puzzle mobile game (see section 2.3.3 Mobile Game Genres, for a discussion on genres and their characteristics).

During the prototype development phase various methods were utilised from the domains of qualitative research, usability evaluation and software engineering. Following, these methods are discussed along with other aspects of the game development process.

Review of Existing Theory

A review of extant theory was conducted to gather materials for the content design of the game prototype. Existing literature was examined and findings were used to frame the design of the learning objectives of the game. Initially types of games and types of learning outcomes suitable for the context were considered, followed by a review of literature on language learning theory, mobile-assisted language learning

and puzzles as vocabulary learning activities. From this collection of resources, input was extracted and applied to the design of the game content.

Game Development

The development platform selected for the game was Unity as discussed further in Chapter 6 (Designing Mobile Game-based Learning). Furthermore, the development methodology used was an iterative one and involved two development cycles. On completion of the first iteration, a series of reviews were conducted to assess the interface and functionality of the game as well as to determine how well it fitted the design requirements. The two types of reviews initially conducted are commonly used in assessing game-based learning and included expert evaluations and one-to-one play tests with a number of potential learners from the intended user base (Connolly et al., 2009). Following, an additional review with learning experts took place, which provided insight on the learning potential of the game and the learning content. Findings from these reviews then informed the final iteration of the game. Conducting reviews early on during development is considered important for instructional applications, to inform design direction but also to ensure the process is consistently iterative (Braden, 1992).

Play testing

As previously mentioned in-between the two iterations of the game prototype, play testing was conducted, in the form of expert reviews. When evaluating game-based learning, expert reviews are usually conducted early on in the development process and often focus on learning content, technical quality and accuracy (Connolly et al., 2009). The primary goal is to get reviewers to highlight things that could be better and offer correctional advice (Connolly et al., 2009). Here, the method employed for the first two steps of the play test was the think aloud protocol, while for the third step the review was conducted in the form of a presentation of the prototype followed by a feedback session. Findings yielded by the first two steps of the play testing focused on issues with game functionality, usability and interface, while those yielded from the third step focused on the learning potential of the game.

Think aloud

Think aloud was performed with expert reviewers and potential game testers. The think aloud protocol is a method commonly used in usability evaluations to obtain insight into the user experience (Nielsen, 1993). It can however be used in other context according to the specialisation and focus of the reviewers as further discussed in Chapter 7 (Developing Mobile Game-based Learning). The method consists of the user verbalising thoughts, expectations and perceptions while performing tasks on a particular application. An administrator, or in this case the researcher, sits next to the reviewer prompting him/her to keep talking and observing performed actions. Twelve reviewers in total participated in the play test, eight of which were subject experts and four were potential players. They were given brief summaries of the think-aloud protocol and asked to play the game. The think aloud session was audio recorder to aid later analysis, while notes were also taken from the researcher who was observing the play test. Findings from the think aloud were grouped with those gathered during the expert review and assisted the compilation of a list of fixes, which were implemented for the second iteration of the development.

3.2.3 Evaluation

The game prototype developed was based on both the design guidelines synthesised on the first stage of the research as well as the qualitative research conducted on the previous stage. In the final evaluation of the game, the opportunity occurred to validate research hypotheses on the suitability of the tool for the context, as well as the guidelines developed, which informed the game design. In terms of explicit outcomes the aim was to investigate the effectiveness of the game, which concerned examining engagement and usability instead of learning as such. In Chapter 8 (Evaluation), a case is made towards evaluating engagement and usability instead of direct learning in order to assess the effectiveness of a mobile game-based learning application. This approach was supported by the links between levels of engagement

with a game and learning from it, provided by the literature (Lepper & Malone, 1987; Jacques et al., 1995; Whitton, 2010), as well as arguments supporting the importance of a system's usability for learning effectiveness (Kukulska-Hulme, 2005; Kukulska-Hulme & Shield, 2004). Nonetheless, it was felt important to attempt to identify possible indications or learning as well, which could support the potential of the framework and make a stronger case regarding the effectiveness of *Lexis* for language learning (see section 8.4 Indications of Learning). Furthermore, it was also the aim of the evaluation to gather qualitative data on participants' perceptions about the experience and their attitudes towards learning with a mobile game.

To address these objectives and considering the lack of a singular method for measuring the effectiveness of mobile game-based learning, a mixed methods approach was adopted. As such, a large-scale quantitative evaluation was conducted examining player engagement and design effectiveness, extended by a smaller scale qualitative evaluation of participants' thoughts and experiences while playing the game and their reflections immediately after. Given however the small scope of the study it was decided to focus on participants' short term attitudes and perceptions and not to measure any possible longer term impact of the intervention. Fifty (50) participants in total took part in the quantitative evaluation, where data were collected via play testing the game and then completing a questionnaire. Out of those, twenty (20) participants undertook the additional qualitative evaluation, which on top of the play testing and the questionnaire, it involved think aloud and an interview.

Questionnaires

Questionnaires are a common tool for data collection in quantitative investigations and they are typically used to sample a portion of the population to make generalisations (Creswell, 1994). A Likert scale questionnaire was used to measure engagement and usability. The questionnaire featured seven (7) introductory questions, eighteen (18) questions measuring engagement and sixteen (16) questions measuring usability. The engagement questionnaire developed by Whitton (2010, p.

112) was used for the engagement questions while the usability questions were developed based on criteria extracted from the design guidelines synthesised and presented in Chapter 5 (Developing Design Guidelines for mGBL).

Think aloud

As previously mentioned, the think aloud protocol is a method commonly employed in usability evaluations to obtain insight into the user experience (Nielsen, 1993). Here, think aloud was used as a qualitative form of evaluation to detect participants' preferences, opinions and reasoning not observable via the questionnaire. Participants were given an introduction of the think aloud protocol and what was expected of them and were then left to play test the game. Audio was recorded during the play test, to assist later data analysis.

Observation

A standard form of data collection within qualitative research is participant observation (Creswell, 2003), though observations should be primarily used to support rather than substitute an analysis (Booth et al., 2003). Observation took place while participants were play testing the game and thinking aloud during the qualitative evaluation, to support other evaluation activities. During this time the participant was seated at a desk holding the mobile testing device (iPhone) and playing the game, while the researcher sat behind and to the right, taking notes. A laptop was positioned in front of the participant, remotely recording the screen of the mobile device using the Airplay third party mirroring application X-Mirage. Mirroring the device screen on the laptop screen allowed the researcher to see the actions of the participant in the game. A microphone was also connected to the laptop digitally capturing audio. Observation thus provided the chance for the researcher to examine gameplay as it happened and to note any key insights verbalised by the participant. Data collected were primarily descriptive, hand-written notes concerning the experience of play.

Interviews

Interviews are probably the most widely employed method in qualitative research (Bryman, 2004). Directly following play testing, interviews were conducted with participants who undertook the qualitative evaluation. Interviews lasted for 10 to 20 minutes and the game was left running, so that participants could illustrate points made during the interview, if desired. Interviews took a semi-structured form since although the interview followed a predetermined line of questions, room was left to pursue other lines of discussion if they arose. Semi-structured interviews typically refer to a context where the interviewer has a series of questions in the general form of an interview schedule, but is able to vary the sequence and has some latitude to ask further questions in response to what are seen as significant replies (Bryman, 2004, p. 113). Interview questions focused on aspects of game playing, the play testing itself, attitudes towards learning with a mobile game and predicted patterns of use of mobile game-based learning. The interview was considered important to provide additional reflective data and complement the more immediate nature of the think aloud.

Further details on the evaluation and its data collection methods can be found in Chapter 8 (Evaluation). It becomes obvious however that a range of qualitative and quantitative data collection and analysis methods were used for the three phases of this research. The next section considers ethical issues associated with the research, while the final section provides an overview of research limitations.

3.3 Ethical Consideration

This section considers possible ethical issues relevant to undertaking this research. It is a requirement at the University of Edinburgh that any research involving human participants must be granted approval from the Research, Ethics and Knowledge Exchange Committee; for the parts of this research therefore requiring human input, consent was sought in advance. Additionally, participants were supplied with clear information on their contribution and how it would aid the research as well as the tasks they were to perform. They were also in all cases provided with consent forms

before participating (see Appendix B). Participation in all stages of this research was voluntary and no incentives were provided. Participants were treated as anonymous and their identities were not concealed at any point, while they also retained the right to withdraw from the study. They were also made aware that although publications could be generated from this thesis, identities would remain concealed and data would be presented anonymously.

In total, four hundred and seventy four (474) participants took part in various stages of the research, and their involvement can be seen in the following table.

Research Phase	Involvement	Number
Theory Development	Background Study	403
Prototype Development	Expert Review	8
Prototype Development	User Testing	4
Prototype Development	Learning Review	9
Evaluation	User Evaluation	50

Table 3-1: Participants in various stages of the research

All of the participants who took part in the prototype development and the evaluation phases of the research were recruited by word of mouth. Participants who contributed to the prototype development phase were primarily friends and colleges of the researcher, while the learning reviewers were members of the LAER (Learning and Adaptive Environments Research) Lab of the University of Edinburgh, of which the researcher is a member. All of the participants with the exception of those who contributed to the background study were provided with written information about the research and the nature of their participation when asked to sign the consent form, as previously mentioned. All participants (excluding those contributing in the background study) spent time face to face with the researcher, thus had the opportunity to discuss the research and to ask questions and make clarifications if required. Finally, the participants who contributed to the background study and conducted the online survey were recruited electronically and undertook the questionnaire remotely. The landing page of the survey however, provided written information on the study and the reassurance on the anonymity of the respondents.

Furthermore, the researcher's contact details were provided in case any of the remote participants required more information about the study and the handling of data. It is therefore believed that the study did not at any point pose any ethical concerns, since participation has been voluntary and anonymous throughout.

3.4 Limitations of the Study

Limitations and delimitations of this study must be identified and are here discussed. Though some of the following are also addressed at appropriate points elsewhere within the text, it was felt important to group and overview them in the discussion about the research methodology as well.

Target Audience: This research was targeted at adult learners, which by definition is a broad categorisation. Though this categorisation is at certain points during the research stages brought down to a more specific age group, it still remains quite broad. Although the game prototype has been developed with this in mind and designed to appeal to a wide range of users, the generalisability of the evaluation findings should be treated with care. Scope therefore exists to run evaluations with various adult age groups in future work, to determine the extent of generalisability of the results amongst specific age groups.

Demographics: As discussed in Chapter 6 (Designing Mobile Game-based Learning), the game prototype for vocabulary development was designed for intermediate to advanced users of the English language. During the evaluation phase however, this variable was not controlled and participants self identified their level of language competence. This may have influenced their perceptions according to their level of language command, however the variable was not controlled for two reasons. First, due to pragmatic limitations of the short time frame of this research and second since the game prototype was designed to be adaptable to player skill and was therefore considered suitable for a wider range of language learners in comparison to other digital tools for vocabulary building.

Time Span of Evaluation: The game prototype developed for this research, has been designed to be playable more than once. The overall game architecture and gameplay design have been based around principles of replayable micro-content, thus repeated exposure to the game is expected in a real world context. Each participant however only played the game once if conducting a quantitative evaluation or twice if conducting a qualitative one. Furthermore, responses on the play experience were provided immediately after playing, and thus they reflect attitudes and intentions as opposed to solid beliefs. It is therefore expected that long term repeated exposure to the game might yield stronger beliefs and lead to skill development.

Number of participants: A limitation that should be acknowledged is the number of participants for the final evaluation. Though the fifty (50) quantitative and twenty (20) qualitative responses collected could be considered to constitute a large enough number given the pragmatic limitations of a small scale, time limited research study, caution is suggested in any generalisation of the results to the whole adult population. To safely statistically generalise the results to the population a much larger number of quantitative responses would be required, which could not be realistically secured in this instance. As discussed further in Chapter 8 (Evaluation) therefore, the results can only offer information on tendencies and patterns.

Question Wording: One final limitation of the study, which could be addressed in future work, would be the revisiting of the design and wording of certain questions used for the final evaluation, which were less successful in eliciting analysable responses. Time permitted therefore, questions that were previously casually tested could be reviewed via the use of a pilot study.

This chapter has considered the research methodology and described the research phases and data collection methods used for each phase. Additionally it has presented ethical considerations relevant to this research project and overviewed the limitations of the work. The next chapter begins to discuss the original research

conducted and describes the development, data collection method and results of the background study.

Chapter 4

Background Study

To begin the investigation into the potential of mobile game-based learning it was considered important to conduct a background study, in order to gain some further understanding on adults' perceptions regarding mobile games for learning. A background study was therefore conducted at the early stages of this research, to examine mobile devices' circumstances of use, mobile game playing habits and attitudes towards learning via a mobile, game-based environment. This chapter therefore describes the methodology and survey design of the background study and reports on the data collected. A critical overview of the study's implications for the rest of the research is then provided on the final section of the chapter.

4.1 Data Collection Method

The online survey was the selected method for data collection, since online administration provided a route to collecting a large number of returns via a quantitative questionnaire with a large and diverse population. Examining the potential of mobile game-based learning for adults however, meant that the target population would potentially be any adult over the age of 18, which resulted to a very large and diverse population. Since the aim of the background study was to examine general attitudes to support the potential of the framework for further investigation and to also provide indicative results on adults' perceptions however, entry requirements were kept to a minimum to avoid excluding participation. To participate therefore, respondents had to be adults over 18 years old, own a modern mobile device including a feature-phone, smartphone and/or tablet, have internet access available to them, since the background study was conducted on-line and be English speaking, since the language of the survey was English. Thus the population could be described as: *'Any adult aged 18 and over, who owns a mobile device (feature-phone, smartphone, tablet), has Internet access available and is English speaking'*. Geographical constraints were not applied, although the responses

gathered revealed that the vast majority of respondents came from countries of the western world (96%), and the English-speaking world (64%). The three most represented countries were the United Kingdom, the United States and Greece (combined percentage of 77% of participants), which could be predicted based on the existing distributions of the researcher's network of contacts invited to participate. Occupational constraints were also not applied, which resulted to professionals, researchers and students in Higher Education participating to the survey. Finally, other handheld devices or consoles were not examined in this occasion, in order to limit the scope on mobile devices with a purpose other than/not limited to gaming.

Taking the size of the general population into consideration it was necessary to achieve a certain number of responses in order to decrease the margin of error and increase the confidence level for survey results. For a large unknown population over 1million a sample of at least 384 responses is required for a 5% margin of error and a 95% confidence level (see Appendix A). The final number of responses collected was 403, thus this aim was achieved. Achieving a total number of 9513 responses could have been sufficient to securely generalise to the full population since such a response rate would have provided a margin of error of 1% and a confidence level of 99%, however due to the time and resources limitations of a small scale research project, this was not achievable at this point in time. Although the results of this study are not necessarily fully generalisable to the population of all adult learners, it could be concluded that due to the number of responses achieved, the sample size is sufficient to suggest a small margin of error; and at the same time results are generalisable among the participants' subset. Therefore the aim of the background study, which was intended to provide indicative results on the population's attitudes towards mobile devices, games and learning was achieved.

The data collection period allocated to gather the required responses was 6 months (26 November 2012 – 27 May 2013) and during this time the survey remained active online. The tool used for the development and distribution of the survey was Polldaddy Pro. This tool was selected since in addition to basic data gathering and analysis features offered by other tools as well, it also allowed full customisation of

the survey's graphical interface. Design customisation control was particularly important in this case, due to plans to gamify (see Glossary) the survey as discussed on the next section of this chapter. Recruitment for the survey took place via online advertising and calls for participation. Some of the recruitment outlets included University of Edinburgh mailing lists and posters placed around the University campuses, LinkedIn professional groups, social media advertising, corporate world recruitment via peer-connections, word of mouth, forums and e-mail recruitment, and finally the researcher's own professional connections.

Online surveys come with certain benefits as well as limitations, which have been considered when selecting this particular data collection method. Benefits include the ability to generate a high number of responses quickly (Kehoe & Pitkow, 1996) as well as approach a diverse set of participants, while the cost of data collection and analysis is minimised (McCullough, 1998). Additionally, online surveys allow for anonymity (Sheehan & Hoy, 2004), which can be positively motivating for participants and also eliminate the need for an interviewer's participation, thus reducing the amount of bias caused (by the interviewer's mood, opinions and prejudice) (McCullough, 1998). Finally, another benefit of online surveys is their graphic power through web scripting, which can create interesting and attractive questionnaires that compel respondents as well as making them adaptable and interactive (Sheehan & Hoy, 2004). This final benefit has been utilised in the design and development of the background survey in an attempt to make it more appealing and increase the number of responses (the design process is further discussed in the following section of this chapter).

However the use of online surveys in data collection also comes with certain limitations, the first of which is that non-online segments of the population will be underrepresented in the sample (Sheehan & Hoy, 2004). However in this particular case it is highly unlikely that members of the population that own and use modern mobile devices will be the ones without Internet access available, therefore excluded from an online survey method. It would be logical to assume that as the targeted sample for this research is mobile technology users, they are likely to be members of

the online population thus web and computer literate. An additional limitation of the online survey methodology is that it is difficult to generalise beyond those responding, unless a specific amount of representative responses has been achieved (Sheehan & Hoy, 2004). Finally, another limitation of this method is that on-line surveys allow for multiple responses from a single user as well as responses from outside the population (Sheehan & Hoy, 2004). Actions have been taken in prevention of such effects via checking respondents' IP addresses as well as via gathering data on age and location and excluding inappropriate participants from the final result via build-in automatic rule systems. It is recognised that such methods however are not necessarily completely error free.

Online surveys are increasingly becoming a valid data collection method and they should not be dismissed, especially for current research aiming to explore future potential of emerging technologies with a large population. It is here considered that as Internet access is increasingly becoming a default everyday life utility and as more people go on-line, such surveys will continue to be widely used in academic research due to their various benefits for the given context. In conclusion, as Yun and Trumbo (2000) suggest: "the electronic only survey is advisable when resources are limited and the target population suits it". In the following section of this chapter, the design and development of the on-line survey is discussed.

4.2 Survey Design

During the early stages of the online survey development it was decided to adopt a custom design approach, since according to Dillman (1983) an attractive layout is likely to enhance response rates. When considering the type of layout design that would be fit for purpose, it became apparent that an illustrated approach under a gamified aesthetic could work well for the context. Due to time limitations and lack of dynamic content support by the chosen survey development tool however, dynamic game mechanics could not be implemented, so the gamification element would have to be achieved via the graphical environment. The final survey was thus illustrated, incorporating certain game design elements such as character design,

storyline and non-interactive game-like elements such as a heads-up display (HUD), badges, score, etc.

Deciding on the visual style of the illustrations was the next important step regarding layout design. The aim was to create simple, clean and attractive illustrations that would be gender neutral. At the same time however, design had to be vibrant enough to attract interest, thus a cartoon-like, colourful and ‘happy’ look was considered as a suitable approach for the overall graphical interface. For the final illustrations, which can be seen in the following figures, character illustrations were cartoon-like while the rest of the graphics were minimalistic, presented as silhouettes thus providing a modern, stylised feel. The aim was to attempt to maximise compliance, via gamifying the process of taking the survey, through these illustrations. This was considered important in this case since to examine the general attitudes of adults regarding mobile devices’ circumstances of use, mobile gaming and learning via mobile games, a number of questions would have to inevitably be utilised. Through those questions indicative results on adults’ perceptions could be generated which could possibly support the potential of the framework. This notion of the gamified survey is therefore proposed as a general approach to survey design for particular purposes.

The two main characters were designed as 3D models, developed, rigged and textured in the software Blender 3D and then rendered as 2D images. Their design has been influenced by paper cubee crafts (toys made out of folding paper). This type of character design seemed appropriate for the visual style selected due to simplicity, likability and reference to hand-made craft. Both characters’ textures were designed in the image manipulation software Illustrator and then imported into Photoshop for fine-tuning, while they were based on a real cubee craft template. The characters represent a gender-free human, designed to appeal to both men and women and an animal character.

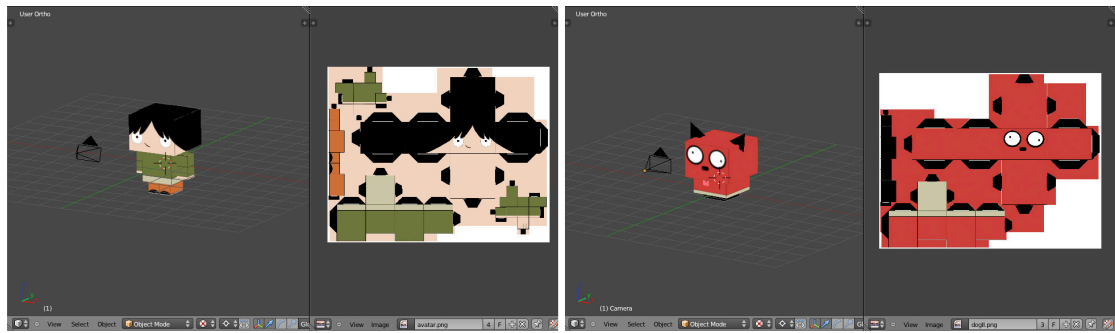


Figure 4-1: Character models inside the Blender 3D interface

Following character design, the next step was to build the story templates. The story was quite simple and involved around the two characters guiding the participant through the survey questions. The questions were divided into five groups according to context (Introduction, Device Usage, Gameplay, Game Design and Learning) and for each one a matching story template was designed. This type of structure worked well as it allowed breaking down the large number of questions into smaller and more manageable sections, each presented in a new survey page along with the relevant story template. Story templates were placed at the footer of every page. An example of a story template can be seen in the following figure:

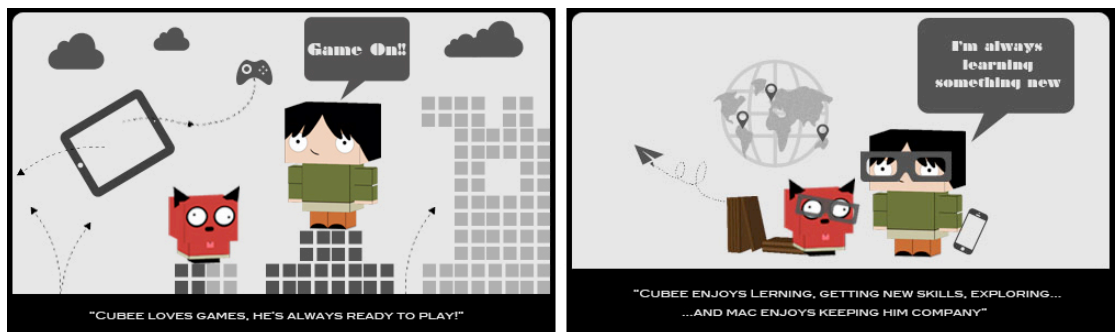


Figure 4-2: Story templates for section 3 (Gameplay) and section 5 (Learning)

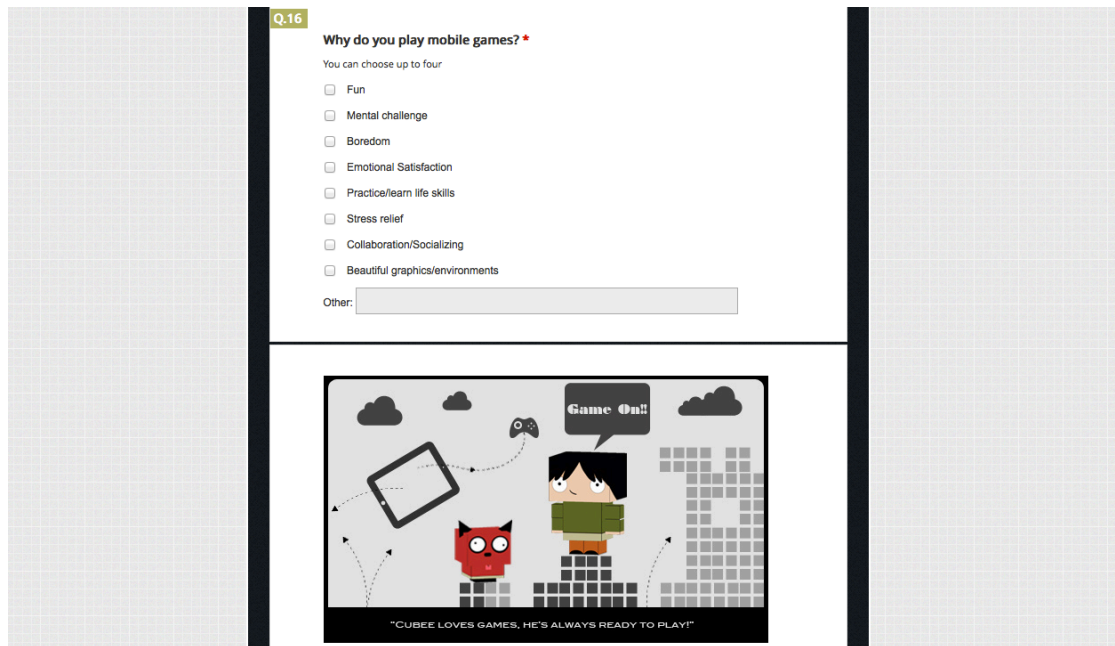


Figure 4-3: Story template as it appeared on the footer of the survey page

A simplified HUD template was designed for the header of every questionnaire page as the last element of custom design. The HUD featured badges and score keeping according to participant's progress in completing survey sections. The five survey sections were presented as game levels and everytime the participant moved on to the next section, a badge was added to the HUD indicating progress and a score point was also awarded. Upon completion of all survey sections and when hitting the 'Finish' button, the title of 'PRO Survey participant' was awarded to the respondent via the survey end screen.



Figure 4-4: HUD as of level one

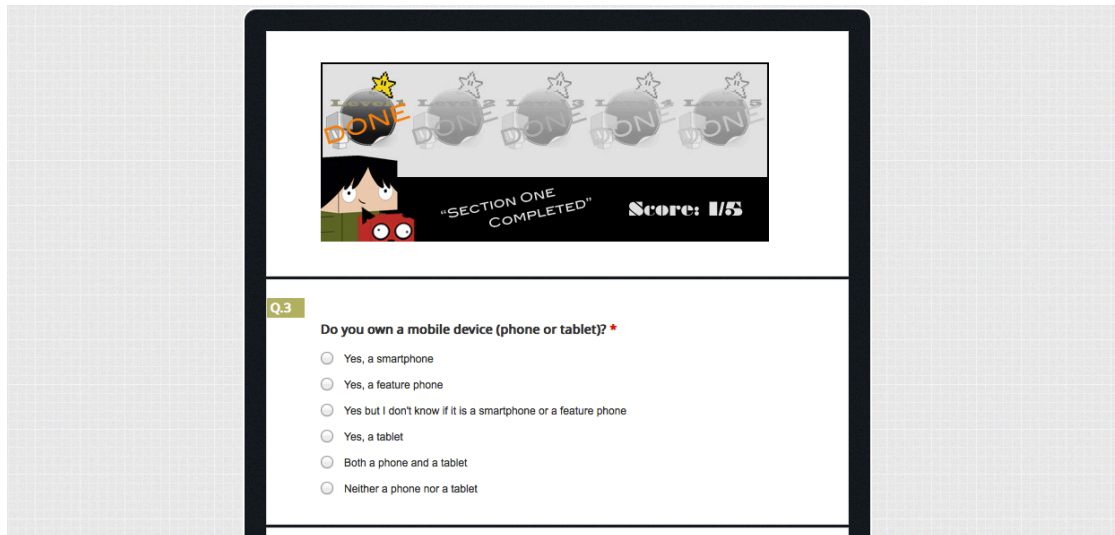


Figure 4-5: HUD as it appeared on the header of the survey page

In order to evaluate the overall influence of the survey design towards participants' motivation to complete the survey, a monitoring question was incorporated at the end of the questionnaire, the results of which can be seen in the following chart.

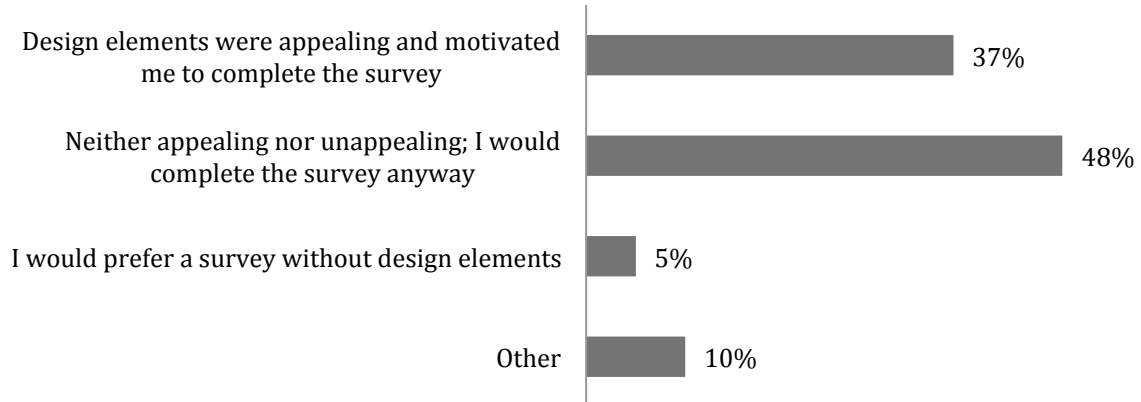


Figure 4-6: Design influence on survey participation

The majority of 48% of respondents indicated that they would complete the survey anyway, however a considerable percentage of 37% of respondents were positively motivated by custom design elements, which they found appealing. It can therefore be concluded that although the design was not the most important factor in attracting survey participants, it arguably played a positive role in maximising compliance since a certain number of respondents could have potentially not participated given the design element was missing. Some interesting comments on the survey design, which were made by participants can be seen below:

First time I complete an illustrated survey. Really like it and I think it makes a difference.

I like it. The design suits the purpose and gives a game-like feel.

Design elements showed that effort had been made - I had chosen to complete the survey anyway but it was good to know that someone cared enough to try to encourage me/make me smile on the way through!

I didn't pay attention to them, skipped the images.

Design elements were appealing, but I would have completed the survey anyway.

Many of the respondents commented positively on design elements, however others indicated that they were not necessarily motivating on their own right. It can therefore be concluded that although visual design is not the primary motivational element of a research survey it can potentially enhance the appeal of an already well-structured questionnaire, the context of which is of interest to the participant.

4.3 Data Analysis

The online survey was made up of a total of 25 questions divided in five sub-sections targeted to examine attitudes towards mobile devices circumstances of use, mobile gaming and learning via a mobile game. As previously discussed, the design of the survey was informed by this division of questions into sections according to theme, and a story template was designed for each section. This type of structure worked well in this context, since it allowed braking down a relatively large number of

questions into more manageable groups. The first section included two introductory questions that helped gather some key demographic information about participants. The second section examined mobile device usage patterns. The third section looked into attitudes towards mobile gaming, while the next one focused on game design preferences. Finally, the last section of the survey investigated attitudes towards learning via a mobile game. The total 25 questions are presented on the table below:

Demographics	
1	Please indicate your age.
2	Please indicate your sex.
Mobile device usage patterns	
3	Do you own a mobile device (phone or tablet)?
4	What type of mobile phone/smartphone do you own?
5	If known indicate the model of your phone.
6	What type of tablet do you own?
7	If known indicate the model of your tablet.
8	How much time do you spend on your phone/tablet on average in a day?
9	What are your preferred mobile activities?
10	Please indicate your five favourite apps.
Attitudes towards mobile gaming	
11	Have you ever played a game on your phone/tablet?
12	Do you play games on your phone/tablet now?
13	Name some of your favourite games you've played recently.
14	How often would you say you play mobile games?
15	How much time do you spend playing a game on your phone?
16	Why do you play mobile games?
Attitudes towards mobile game design	
17	What type of mobile games do you prefer to play?
18	Which game characteristics are the most important to you?
19	Which are the features of a mobile game you would find most appealing?
20	Would you say you play games on your mobile device more often than on other devices (e.g. computer, console)?
21	What would make you choose to play a game on a mobile device rather than a computer/console?
Attitudes towards learning	
22	Would you use a mobile game to learn?
23	How appealing would you find the idea of learning using a mobile game?
24	If you were to use a mobile game to learn, which topics would you find most suitable for the context?
25	As an adult learner what would be your main learning priorities?

Table 4-1: Background survey questionnaire

The results revealed a relatively even number of male and female participation, with most participants falling into the 21-29 years age group, immediately followed by the 30-39 years age group. Results comply with demographics for casual games played on mobile devices, according to which most gamers are between the ages of 25-34 years old (Casual Games Association, 2012). Furthermore, it appears as though male to female participation to the online survey aligns to recent statistics according to which 54% men and 46% women play mobile casual games in the European Union, and 52% men and 48% women in North America (CGA, 2013).

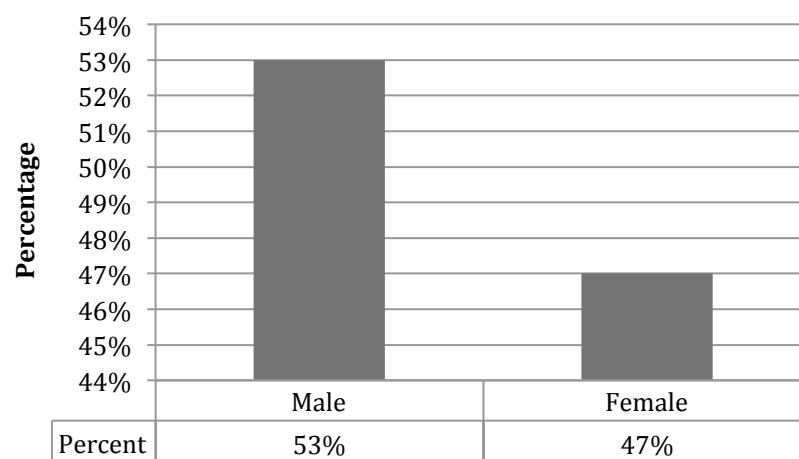


Figure 4-7: Male to female participation in the survey

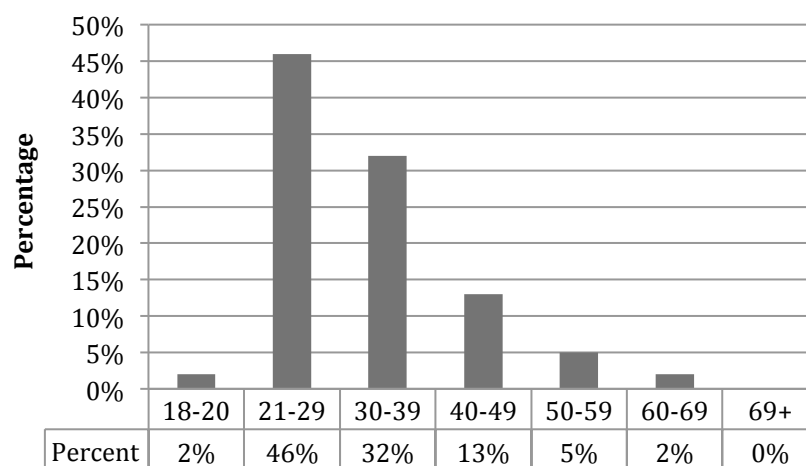


Figure 4-8: Survey respondents by age group

Regarding location demographics, the majority of participants came from the European Union and North America, with the three top countries represented being the United Kingdom, Greece and the United States. In the following chart the top 8 countries with regards to numbers of participants are presented. Overall a total of 38 countries were represented in the results, however the countries following the top 8 had a total percentage of 1% or less in the final results.

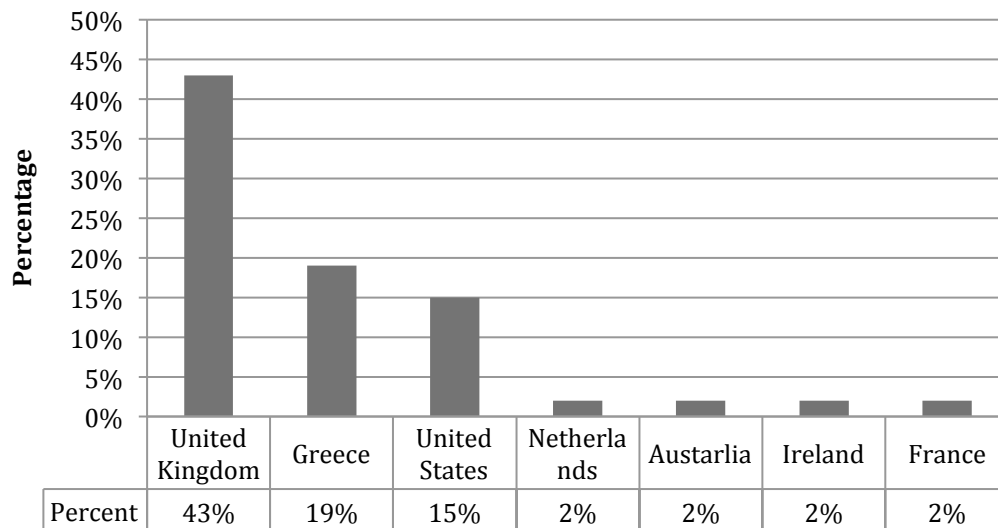


Figure 4-9: Countries most represented in the survey

Initially participants were asked to verify whether they owned a mobile device and indicate the type of device they owned. 55% responded that they owned a smartphone, while 30% indicated that they owned both a smartphone and a tablet. Feature phones were owned by 5% of respondents, while only 4% indicated that they did not know whether the phone they owned was a smartphone or a feature phone. This signified that the distinction is nowadays recognised by most mobile users. Only 4 participants (1%) said that they owned neither a phone nor a tablet, which leads to the assumption that the vast majority of adults today own a mobile device, supporting claims made regarding mobile devices' adoption rate amongst contemporary adults, as proposed in section 2.1.2 (Mobile Learning). Furthermore, this complies with statistics with regards to device ownership, according to which more than 6 billion mobile phone connections existed at the end of 2011 worldwide, expected to grow to 12 billion by 2020 (ITU, 2012).

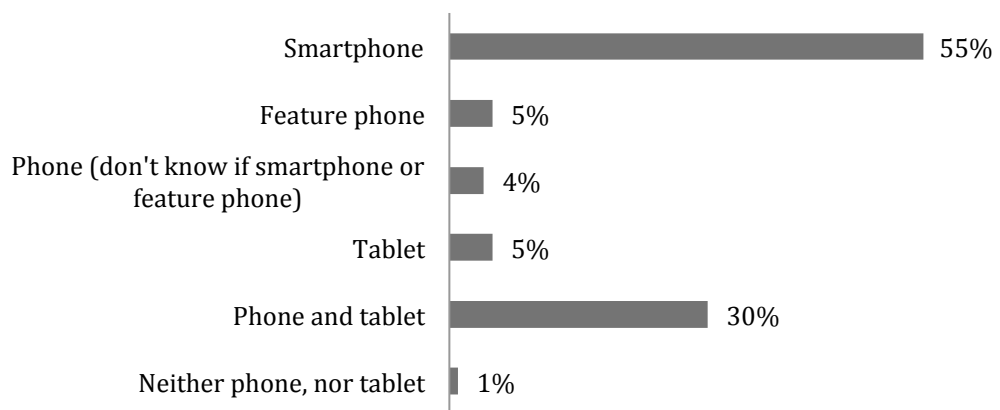


Figure 4-10: Types of mobile devices owned by participants

When asked to indicate the type of mobile phone they owned the two most popular operating systems were iOS at 41% and Android at 39%.

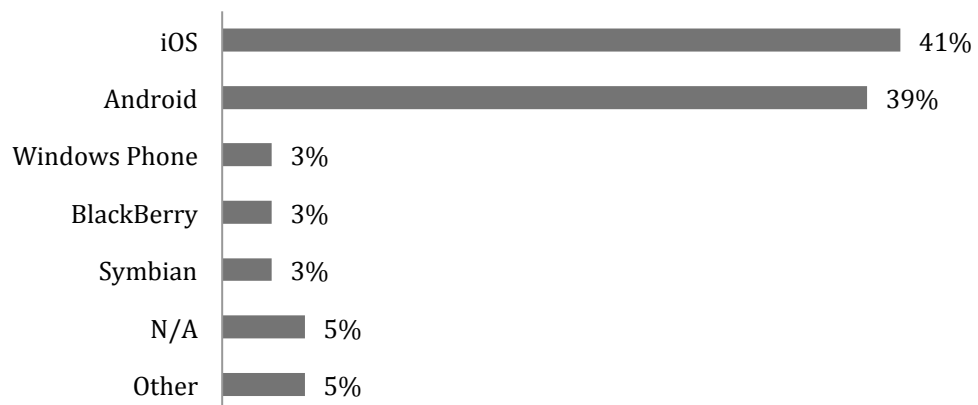


Figure 4-11: Types of mobile phones owned by participants

In a relevant subsequent question, survey participants were also asked to indicate the exact model of their phone, if know. Some of the most commonly indicated models were the iPhone 4, 4S, 5 range and less commonly the iPhone 3GS followed by the Samsung Galaxy including models like Ace, S2, S3 and Nexus, the Nokia Lumia,

HTC and various models like Inspire, Desire, One, etc, the Sony Xperia and less frequently the Blackberry range including Curve, Torch, etc.

When asked whether they owned a tablet or not, more than half of the participants replied they did not. Among tablet owners most owned an iOS tablet (29%), followed by those who owned an Android one (9%).

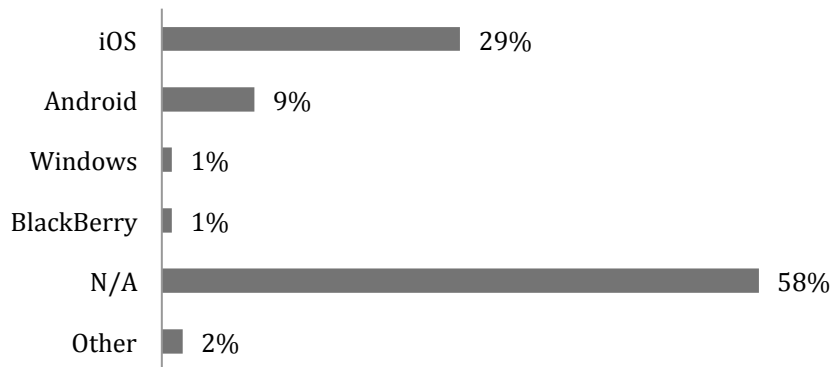


Figure 4-12: Types of tablets owned by participants

Next survey participants were asked to indicate the exact model of their tablet, if know. Not surprisingly the most common model was the iPad, while some other indicated models were the Samsung Galaxy Tab, Google Nexus, Microsoft Surface Pro, Kindle Fire, Blackberry Playbook and ASUS Transformer.

The next question asked respondents how much time they spend on their mobile device on average per day, excluding calls (when replying regarding a mobile phone). Replies indicated that 34% spend 30min to 1hour and 29% spend 1.30hour to 3hours. An average of less than 30min or more than 3hours was less common.

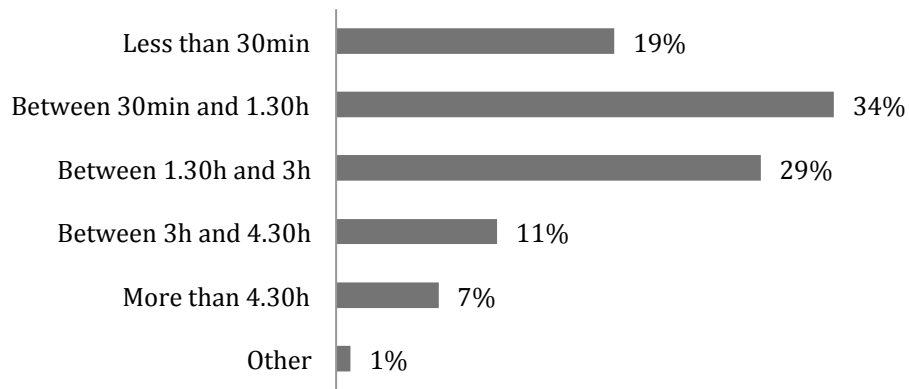


Figure 4-13: Average time spend on mobile phone daily (excluding calls)

Examining participants' most frequently performed mobile activities, e-mails, web browsing, talking/texting and social networking were the four prevailing responses. E-mails at 19% were slightly more popular than both web browsing and talking/texting which each got a percentage of 17%. Social networking came fourth at 16%. Encouraging was the fact that playing games was the fifth most popular activity, with a percentage of 12% and a notable difference in frequency in comparison to the following responses which were taking photos/videos and reading, each at 8%.

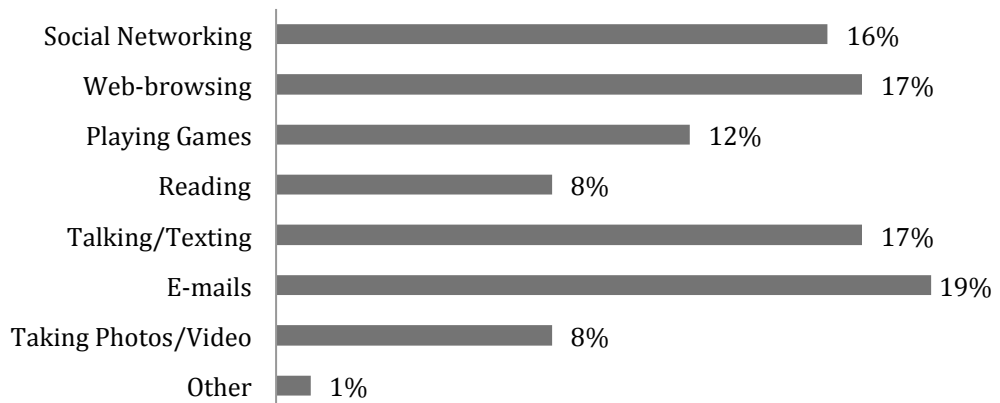


Figure 4-14: Most frequently performed mobile activities

In a relevant next question, participants were asked to indicate their five favourite mobile applications. Some of the most popular were Gmail, Viber, Google Maps, Whatsapp, Youtube as well as Facebook, Twitter, Instagram, LinkedIn, etc. Overall the most popular application categories were social media, communication, travel and transportation, fitness, utilities like the calendar and weather app, note taking and various games.

The next set of survey questions examined mobile gaming habits, and initially asked how many of the participants had ever played a mobile game on their device. The majority of 92% responded positively.



Figure 4-15: Response rate on ever playing a game on mobile device

When asked to indicate whether they were currently playing a mobile game on their device, the overall percentage changed, however a majority of 64% of participants still replied positively. The fact that the majority amongst a diverse range of participants indicated that they currently played games on their devices, complies with arguments made on the potential of the mobile game-based learning framework proposed earlier in this thesis, based on its player appeal (see section 2.4 Mobile Game-based Learning). It therefore appears as though a casual way of play makes mobile games more appealing to a diverse population, more representative of an overall adult population.

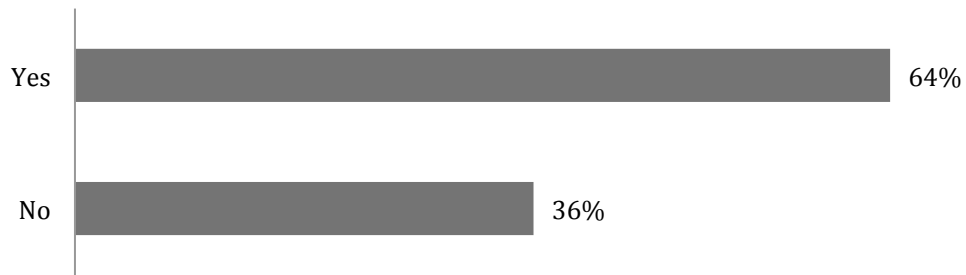


Figure 4-16: Response rate on currently playing mobile games

Respondents were next asked to indicate the names of some of their favourite mobile games they had recently played. Some game names that came up often in replies were ‘Angry Birds’, ‘Bejeweled’, ‘Cut the Rope’, ‘Plants VS Zombies’, ‘Temple Run’, ‘Tetris’ and various word puzzles.

When asked how often they played games on their mobile devices, 23% of respondents said that they played a few times per week and 21% that they played a few times per month. 17% replied that they played more than once a day and 15% replied once a day. The lowest percentage was 7% and corresponded to those playing once a week. According to the results, a frequency of once a week or once a month was the most common, however there was still a considerable percentage of users who played once or more than once a day.

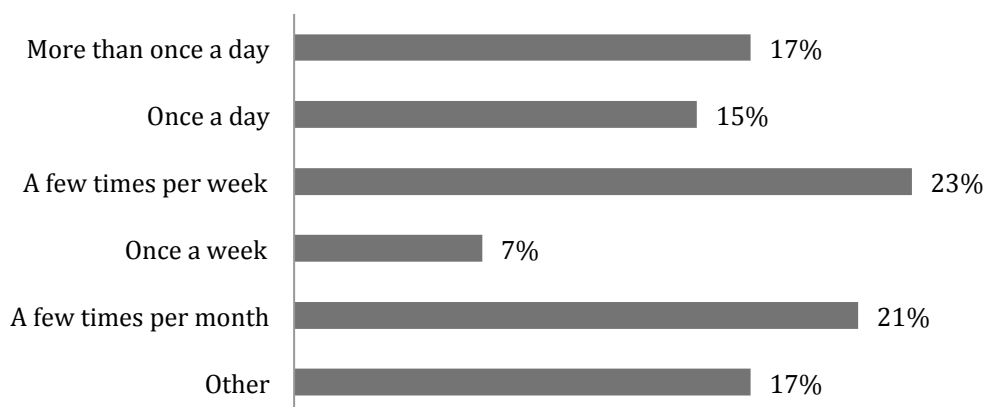


Figure 4-17: Frequency of mobile gameplay

Next, participants were asked to indicate how much time per session they spend playing a game on their mobile devices. The two most popular answers were ‘around 10-20min’ (36%) and ‘less than 30min’ (31%), followed by ‘around 20-30min’ (13%). Interestingly, a relevant recent study on British gaming habits indicates that the average Briton spends six hours per week playing games (Stuart, 2014). Though play sessions seem to therefore be short, they can add up to a considerable total playtime, when frequency is accounted. Furthermore, short play sessions can be associated with casual play patterns, since casual games are designed for short burst of play (Whitton, 2010) and they are often played for a few minutes as they are easily stopped and restarted.

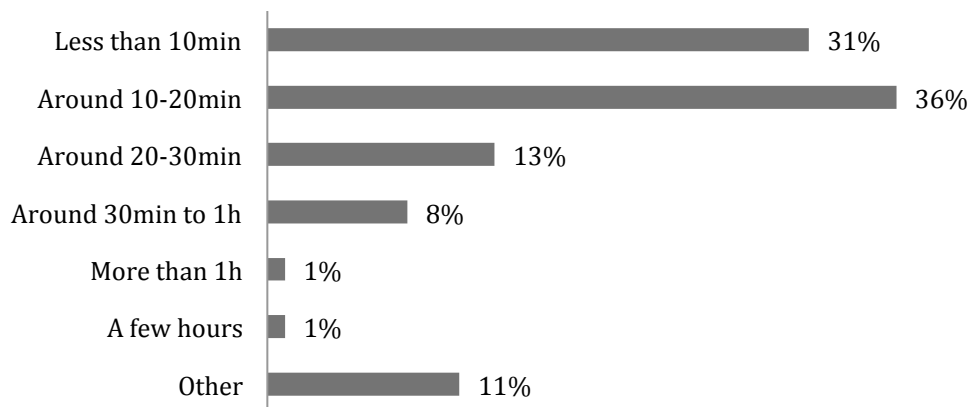


Figure 4-18: Average time per play session

The following question examined participants’ motivations for playing mobile games. The four most popular responses were fun at 29%, boredom at 22%, mental challenge at 15% and stress relief at 15%. Less common responses included graphics/environments at 4%, emotional satisfaction and collaboration/socialising at 3% each, as well as practice/learn life skills at 2%. The most common ‘other’ response indicated was passing time while traveling or commuting.

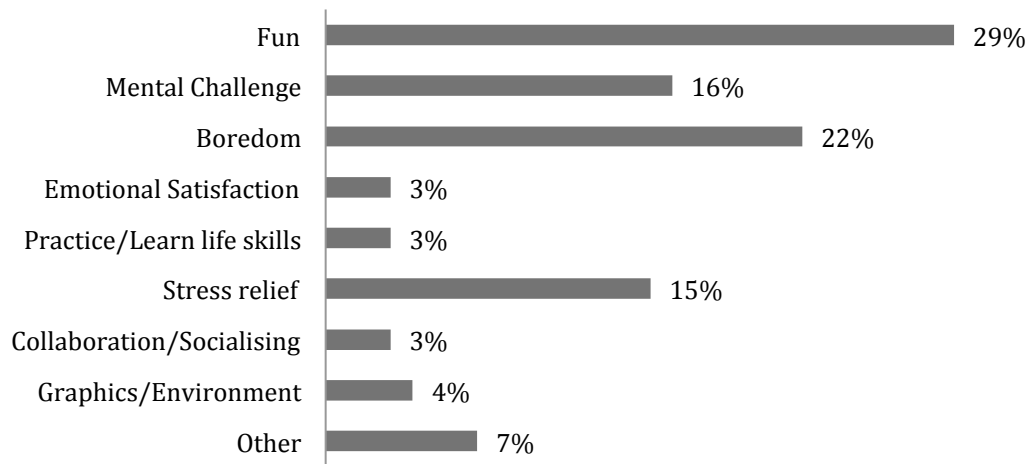


Figure 4-19: Motivations for playing mobile games

When it came to the type of mobile game most participants preferred to play, ‘puzzle’ turned out to be the most popular with 26% of respondents indicating it was their preference. Other popular types were ‘strategy’ at 16%, ‘arcade’ at 15% and ‘adventure’ at 10%. Among the less popular types of mobile games were ‘trivia’ and ‘action’ at 9% each, followed by ‘card’ at 7% and ‘social’ at 5%. It seems therefore that ‘puzzle’ games are by far the most popular type when it comes to mobile devices, followed by ‘strategy’ and ‘arcade’.

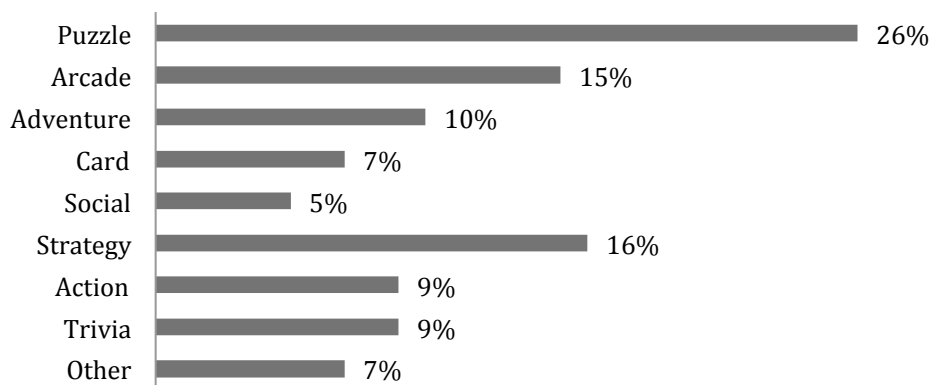


Figure 4-20: Preferred type of mobile game

Survey respondents had to next identify the characteristics of mobile games that were the most important to them. ‘Challenge’ was by far considered the most important, with 32% of respondents favouring it. ‘Interaction’ and ‘Graphics’ followed with 18% and 16% respectively, while ‘Theme/Genre’, ‘Exploration’, ‘Story’ and ‘Rules’ were less popular. ‘Multi-play’ was considered the least important characteristic, indicating a single-player attitude towards mobile gaming.

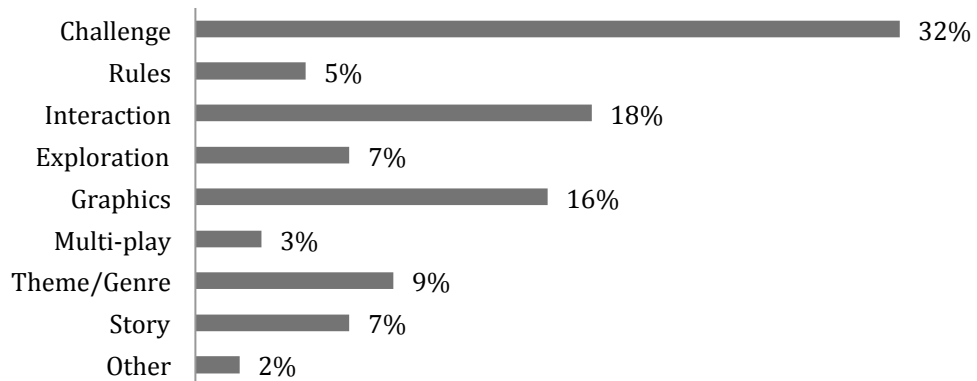


Figure 4-21: Game characteristics most important for play

With regards to mobile game features considered as the most appealing among respondents, ‘ease of use’ at 24% and ‘price’ at 22% came first. Other appealing features were ‘short play sessions’ at 15%, ‘intuitive interface’ at 14% and ‘accessibility’ at 13%. On the contrary, ‘interruptibility’ and ‘gesture controls’, at 8% and 3% respectively, were among the less appealing features.

Overall, key characteristics of casual games were also indicated as appealing features of mobile games, which supports links between casual and mobile. The ease of use and the ability to “pick up and play” (Juul, 2009), along with accessibility (Trefry, 2010), short play sessions and intuitive controls (IGDA, 2009), were indicated by survey respondents as factors for choosing to play a mobile game.

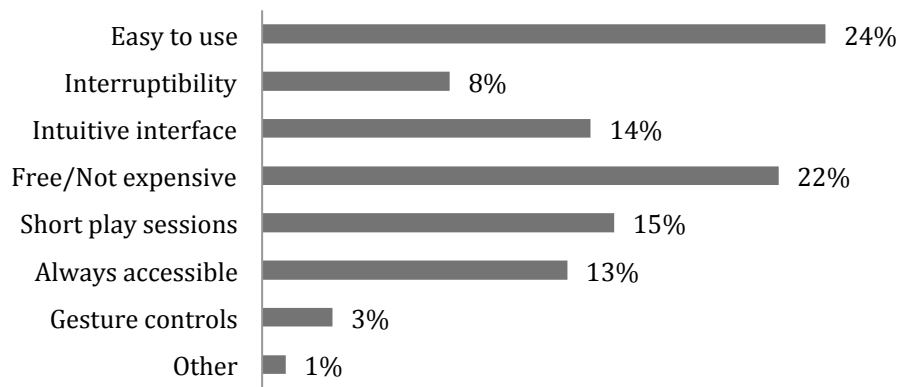


Figure 4-22: Mobile game characteristics most appealing to survey participants

Interestingly in the following survey question, 54% of all participants responded that they play games on their mobile devices more often than on other devices (e.g. computer or console), which supports the potential of the mobile platform as a strong contestant among contemporary gaming platforms. A recent study on British gaming habits also indicated that 54% of respondents preferred to play on their mobile phones rather than on other platforms (Stuart, 2014). Results from both surveys, support claims that casual gameplay is common on mobile devices, which according to Tams (2006) is to be anticipated, since mobile gaming has already been labelled as casual gaming.

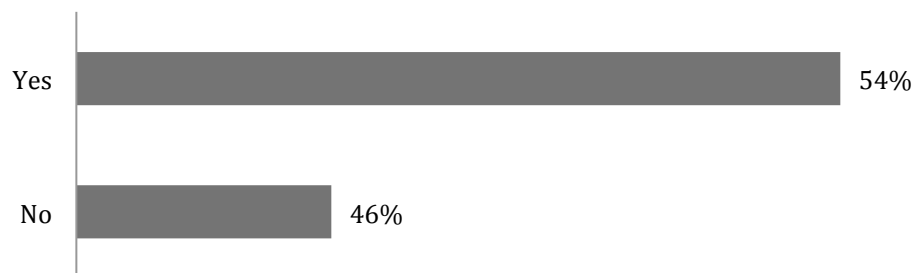


Figure 4-23: Response rate on mobile platform preference over other platforms

In order to further examine this tendency, the following open-ended question asked respondents to comment on what would make them choose to play a game on a mobile rather than any other device. Some of the responses are presented below:

Accessibility and ease of use, plus I find them more engaging overall. Never actually played games on other devices, started playing when I got a smartphone.

I like mobile games cause they are easy to use and can play for a short period of time. No long quests and such, easy to pick up and play for a short while.

Cool gestures, features that are integrated with my environment (location, noise level).

I like mobile games better. They are easier and friendlier to the non-gamer. I can play and enjoy them without too much game conventions knowledge or involvement.

Something that's easy to pick up and put down – if I want to play an RPG or a shooter that I can be engrossed in, I will play this on my PS3 or XBOX360. Also, people on consoles are way too competitive and take it too seriously.

I think this comes down to context. I play games on my commute or relaxing at home – in these settings I tend to use my mobile rather than laptop.

I play games on the device they are best suited for.

The type of game. Would never consider iOS a suitable platform for a first-person shooter due to its lack of controls – would always use a console for such games. Conversely, I'd always play smaller puzzle and word games on iOS because of the simplicity and less effort it takes to load it up and start playing.

Overall, responses revealed three major tendencies amongst participants; those who favoured mobile devices for playing, those who favoured other devices, and those who were open to using any device according to context. However more than half of the survey participants replied that they played games on their mobile device more often than on other devices and indicated some key benefits for choosing to play on a mobile device, such as ease of use, accessibility and short play sessions. Additionally playing on a mobile device seemed to appeal to users who did not necessarily consider themselves as gamers (see Glossary), and might not play or have ever played games on other devices. This is quite encouraging, as it supports the hypothesis that mobile games could be appealing to a wider and more diverse audience of users. It is also encouraging the fact that a number of respondents were

willing to use different devices according to context, which means that if a game is designed to be played on a mobile device and the circumstances of use fit the mobile context, it is likely to be more appealing to users.

The final set of survey questions examined attitudes towards mobile game-based learning. Results were encouraging and revealed a positive attitude towards learning with a mobile game. 83% of survey participants replied positively when asked whether they would use a mobile game to learn. This is quite interesting given the fact that on an earlier question, 64% of respondents replied that they currently played games on their devices, while 36% replied that they did not, which indicates that although a number of respondents do not currently play mobile games they would still be positive to using a mobile learning game. Furthermore, encouraging was the fact, that these initial results were supported by data collected during the user evaluation that took place, as the final stage of this research (see Chapter 8 – Evaluation).



Figure 4-24: Response rate on attitudes towards using a mobile game to learn

The next question asked participants to indicate how appealing they would find the idea of learning using a mobile game. Results indicated that 39% of respondents found the idea very appealing and 36% appealing. 18% replied neither appealing, nor unappealing, while the results for finding it unappealing and very unappealing were lower, at 4% and 3% respectively.

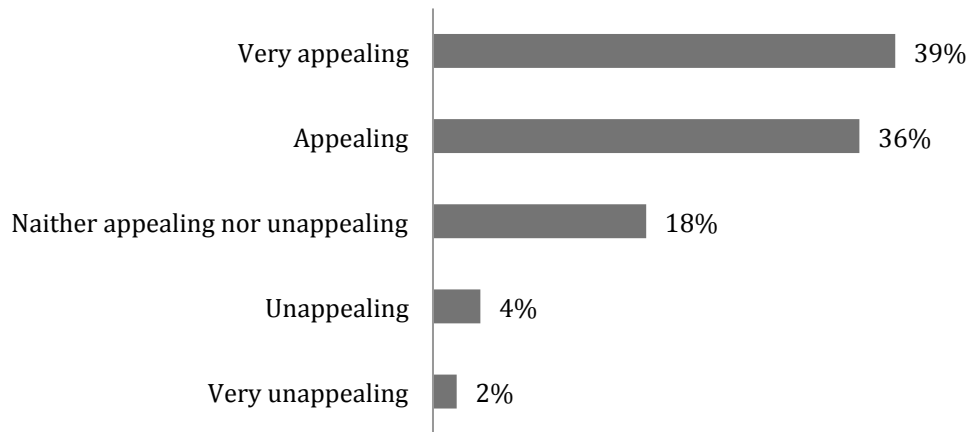


Figure 4-25: Response rate on the appeal of using a mobile game to learn

In the following question, participants were asked to indicate the topic they would find most appropriate for the context of learning via a mobile game. Language was the most popular response with a percentage of 31%. History at 18% and Life Skills at 17% followed, while IT and Mathematics/Physics at 13% each were less common responses. Alternative topics indicated as ‘Other’, had to do with Design/Art/Music as well as Environmental issues and Geography. Some participants also indicated they would like topics that had to do with improving brain functions like memory, or work related training.

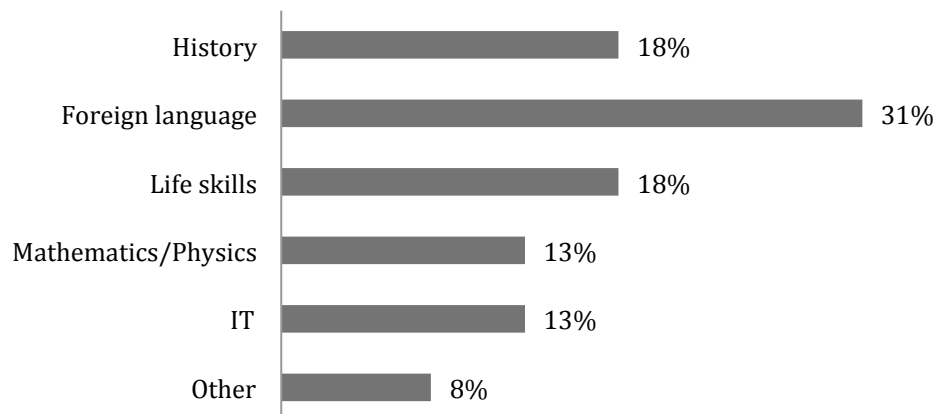


Figure 4-26: Topics considered appropriate to learn with a mobile game

The final question of the survey examined the main priorities of adult learners. Participants were asked to indicate what would be their main learning priorities and flexible learning was the most common response at 28%, followed by personalised learning adapting to the skill level of the player at 20% and then by transferable learning for real life needs at 18%. Less common responses were self-direction at 15% and choice over learning materials at 10%. Social interaction, collaboration and sharing were the least frequent indicated priority, with a percentage of 8%.

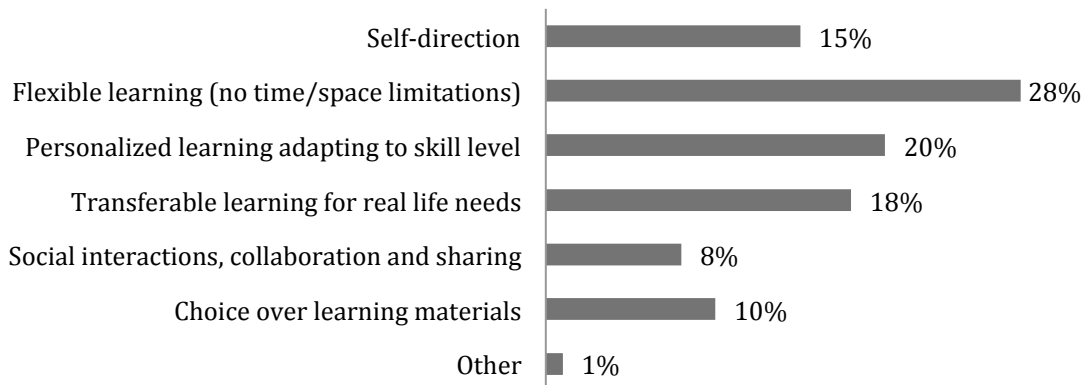


Figure 4-27: Learning priorities among adults

4.4 Discussion

The background research described in this chapter has supported initial considerations on the potential of mobile games for adult learning, with 83% of survey respondents saying that they would use a mobile game to learn. Additionally, more than two thirds of survey participants found the idea of learning via a mobile game appealing or very appealing and less than 10% indicated they would find it unappealing. Furthermore, the study revealed that 92% of mobile device owners had played a game on their device at some point, while 64% currently played, which supported the hypothesis that adults who own a mobile device are likely to engage in mobile gameplay. Additionally, playing games was among the five most common mobile activities after checking e-mails, talking/texting, web browsing and social networking. At the same time, 54% of respondents indicated that they played games

on their mobile phone or tablet more often than on other devices. This is encouraging for the purposes of this study since it reveals the potential of mobile devices as gaming platforms, amongst contemporary adults. The fact that many of the survey participants responded that although they did not play games on their mobile device, they would still be positive to using them to learn is particularly encouraging and supports the rationale for using mobile games for adult learning. Finally links between mobile games and casual play were observed, supporting arguments about games on the mobile platform being well suited for the casual gamer (IGDA, 2005), since although a good percentage of mobile players might not be gamers in the classic sense, they would still fall into the more general umbrella of casual gamers (Unger & Novak, 2012). The above observations supported the suitability of casual games for the proposed framework of mobile game-based learning, as discussed on the last section of Chapter 2 (Literature Review).

In terms of other implications of the background survey for the rest of the research, findings influenced the design choices of the mobile game prototype, which was to be developed and tested as part of the research. More specifically, the targeted operating system selected for the prototype, the iOS smartphone, was indicated as the most frequent operating system amongst participants' devices (41%). Furthermore, the by far most popular topic indicated as appropriate for mobile game-based learning was language acquisition and the preferred game type was puzzle; both preferences informed the choice of learning outcome and game type of the game prototype as described in Chapter 6 (section 6.1.1 Types of Games for Learning). Additionally, the design took into account the third most popular adult learning priority, which was learning transferable to real life needs, since the learning outcome of the prototype, which was English language vocabulary acquisition, is a skill that could be easily transferred in everyday life. To also comply with the second adult learning priority, which was personalised learning adapting to skill level, the game was developed to dynamically adapt difficulty levels to the player's skill. The game was also designed to be interruptible and playable in short sessions, informed by the 36% of participants who indicated that their average mobile gameplay session was around 10-20min and the 31% of them who indicated it was less than 10min. In

terms of the target audience, the age group finally selected was adults between 21-39 years of age; the most frequent age range indicated by the online survey respondents. Finally, the developed game prototype was a single player game, since according to the background survey social interactions and collaboration were not considered to be crucial in this context. The final design choices for the game however, were also supported by overall research findings and derived from the proposed mGBL framework (see Chapter 2: Literature Review) and the design guidelines for effective and engaging mobile learning games (see Chapter 5: Developing Design Guidelines for mGBL), and are further discussed on Chapter 6 (Designing Mobile Game-based Learning). The key findings of the background survey are presented on the following table:

83% of survey respondents said that they would use a mobile game to learn
39% of respondents said they would find learning via a mobile game very appealing
Language learning was the most suitable subject area indicated for mobile learning games
Flexible learning adapting to player skill was indicated as the learning priority of adults
92% of mobile device owners had played a game on their mobile device/s
64% were currently playing games on their mobile device/s
Playing games was among the five most common mobile activities
54% of respondents played games on their mobile device/s more often than on other devices
41% of respondents indicated iOS as the operating system of their device/s
Puzzle was the preferred type of mobile game
An average play session was 10-20min (36%) or less than 10min (31%)
The majority of survey respondents were between 21-39 years of age

Table 4-2: Summary of survey findings

Thus far, a rationale for the appropriateness of mobile games for adults developing their skills independently has been presented and the results of the background study have been discussed. For the next step of this research, a set of design guidelines, which can inform the design of mobile game-based learning, will be advanced. The following chapter therefore, moves on to synthesise and propose design guidelines for mobile game-based learning and to discuss a review of a number of case studies, used to extract interface and gameplay characteristics, common in popular mobile games.

Chapter 5

Developing Design Guidelines for mGBL

In this research so far a rationale for the appropriateness of mobile games for adult learning has been provided in Chapter 2 (Literature Review). Additionally the analysis of the findings of a large-scale background study has been discussed in the previous chapter (Chapter 4: Background Study). However it was next important to examine how mobile game-based learning could be designed in order to be usable, engaging and support learning.

To advance a set of design guidelines to inform the development of mobile game-based learning, secondary research in the form of existing theory review as well as primary research in the form of case studies' analysis was conducted. The first section of this chapter therefore discusses guidelines synthesised via the review of related theory on areas such as mobile learning design, engaging game-based learning, usability and finally mobile game design. The next section describes interface and gameplay characteristics found in popular mobile games. Finally, these two pieces of work are drawn together and form a set of design guidelines for mobile game-based learning, as proposed in the last section of this chapter.

The proposed design guidelines are available to use in order to support the development of mobile learning games for adults developing their skills independently. They have also been used for the following stage of this research, which was the development of a mobile game prototype to assist hypotheses testing and help conduct user evaluations. The design and development stages of the game prototype will be further described in the following chapters.

5.1 Existing Design Guidelines

This section describes the review of existing design guidelines in four major areas related to the design of effective mobile game-based learning. These areas are mobile learning design, engaging game-based learning design, mobile games usability and mobile game design. For every one of these areas a short review of influential literature on existing design guidelines will be presented. These are then drawn together to form the proposed design guidelines for mobile game-based learning. The final set of proposed guidelines is also informed by the data collected via the case studies analysis as described in the following section of this chapter.

5.1.1 Design Guidelines for Learning

The andragogical foundations for mobile game-based learning have been discussed in Chapter 2 (Literature Review), where the learning theories informing this research have been presented. Those theories frame the wider theoretical context of mobile games for adult learning, and are here drawn together to assist synthesise a set of design guidelines for the development of mobile game-based learning. In order for mobile learning games to be effective they need to be based on a sound theoretical basis of adult learning and also recognise design considerations including usability, engagement and game design; this way they can be effective, enjoyable and context-specific.

The design of games targeted at adults, should consider key principles of adult learning and recognise the need for self-direction, support of diverse learning backgrounds, motivation and real life relevance (Knowles, 1998). Knowles (1984), discussed how andragogical principles could be applied to the design of personal computer training arguing that there is a need for explaining why certain things are being taught, and that instruction should be task oriented, take into account the wide range of backgrounds of the adult learners and allow them to discover things for themselves providing support. It can be argued that these recommendations also apply to personal mobile training. Additionally, as discussed in Chapter 2 (Literature Review) self-direction is important for adult learners and should be taken into

consideration when developing design guidelines for games targeted at them. Fischer and Scharff (1998) discussed five (5) requirements for systems able to support self-directed learning, arguing that such systems should be user-directed and supportive, be sufficiently open-ended, provide means of modification/extension, support a range of expertise and where required, promote collaboration.

In addition to adult learning a key theory informing this research is mobile learning. Naismith and Corlett (2006), proposed four (4) general guidelines for the design of mobile learning based on findings from their research; these include creating quick and simple interactions, using flexible materials, considering the affordances of the mobile device which can enhance the learner experience and using mobile devices for delivering and facilitating learning. Additionally, they identified five (5) factors that are critical to the success of mobile learning projects, which can be summarised in access to technology, ownership, connectivity, integration and support (Naismith & Corlett, 2006). Furthermore, Kukulska-Hulme and Traxler (2007b) discussed ways of thinking about content in the design of mobile learning and proposed eight (8) aspects to consider. These were open-endedness, personalisation, portability, time-critical nature, measured delivery, aural medium, prioritizing medium and alternative medium. Discussing aspects of the mobile learning context, Gibbons, Wang and Wiesemes (2010), suggested that mobile content should be learner-focused, promote autonomous learning and be meaningful and memorable. At the same time Dillard (2012) synthesised a set of mobile instructional design principles for adult learners which are particularly relevant; these include the development of a simple and intuitive interface, the integration of interactivity and multimedia, building short modular lessons and activities, designing activities that are engaging and entertaining, designing content that is contextual, relevant and valuable to the learner and finally considering just-in-time delivery. These principles are targeted at guiding the creation of effective mobile learning, looking at the wider context of development including interface and engagement considerations. In the case of this research however, interface and engagement considerations will be discussed separately in subsequent sub-sections specifically dedicated to mobile usability and the design of engaging mobile game-based learning.

When discussing mobile learning the design of bite-sized information, which allows learning to be organised in manageable chunks, is appropriate for the context. In his open definition of microlearning, Hug (2005) provides seven (7) dimensions of microlearning that could be used to describe, analyse and generate micro-content and can therefore inform the design of microlearning activities. The dimensions proposed are time (relatively short effort), content (small units), curriculum (parts of modules/elements of informal learning), form (fragments/skill elements), process, mediality and learning type (depending on learning activity and wider scope). Furthermore, (Gabrielli et al., 2006) proposed six (6) requirements that should guide the design of both technologies and content of microlearning. They proposed that microlearning should be highly transferable and unobtrusive of the learner's activity, easily available and user friendly, persistent, useful, individual as well as sharable and adaptable to the learner's needs.

Informal and lifelong learning in the mobile context, as proposed by Naismith et al. (2004), were considered to be key theories informing the design of mobile games for adult learning. Looking at the design of lifelong learning tools, Sharples (2000) proposed eight (8) elements that are necessary for technological tools able to support learning successfully. He proposed that such tools should be highly portable, individual, unobtrusive, available anywhere, adaptable, persistent, useful and intuitive (Sharples, 2000). With regards to designing mobile learning Naismith et al. (2004) found that mobile technologies can relate to six types of learning activities. Specifically for informal and lifelong learning, the mobile device should accompany users in their everyday experiences and become a convenient, accessible source of information that assists and/or helps record learning (Naismith et al., 2004).

The principles discussed in the above literature underpin the wider theoretical context of the proposed framework and inform the design of mobile game-based learning for adults. Those principles have been drawn together to form the following guidelines for designing effective mobile learning games for adults:

Promote self-direction

Adult learners need to take charge of their own learning and feel in control (Knowles, 1998). Learning should therefore be user directed and support learners in making their own choices of tasks and goals (Fischer & Scharff, 1998). In this context, the learner should be presented with options regarding the learning tasks, or the ability to modify the learning content to allow customisation of learning to personal needs (Kukulska-Hulme & Traxler, 2007b). In addition, the learning tool should provide learners the ability to build up their knowledge independently, supporting them throughout and providing feedback on performed tasks (Knowles, 1998). Furthermore, the learner should be in control of when to take up learning and also be allowed to self-pace (Knowles, 1998).

Support independent learning

In a mobile context for informal adult skill development, independent learning should be supported (Gibbons et al., 2010). Since learning is highly portable it is available anywhere, and allows the learners to control where and when learning will take place; this is important for a mobile learning context where flexibility is key (Naismith & Corlett, 2006). This way open-endedness is enhanced (Fischer & Scharff, 1998) and learning can take place informally while being integrated in daily life (Naismith et al., 2004). To achieve accessibility and open-endedness the learning tool should be available where and when needed and should therefore be developed for the learner's personal device (Naismith et al., 2004). Finally, the learning system should be individualised and promote autonomous learning skills (Sharples, 2000; Gibbons et al., 2010).

Provide a personalised experience

Mobile devices are personally owned and ideally suited for personalised learning (Kukulska-Hulme & Traxler, 2007b). Due to individual device ownership, mobile learning can be designed to support personal learning and allow learners to monitor their learning progress. Models can be developed as the learner interacts with the system in a lifelong context, which automatically adjust to personal needs and provide data about the learner's skill development over time (Sharples, 2000).

In an adult learning context it is also important to take into account the diversity of the learners' backgrounds and support a range of expertise (Knowles 1998). This is important for lifelong learning as well, since the system will be used over a long period of time and it should be able to cater for learners at progressively varied levels of expertise via adaptability.

Support active, task-based learning

Knowles (1998) supported that adult learners are task oriented; learning frameworks addressed to them should therefore take into account their task-centred or problem-centred orientation to learning and base learning around problem solving rather than memorisation. Games are particularly suited to active task-based learning since they are a medium for learning by doing (Gee, 2003). Games therefore support active learning and are ideal environments for learners to practice, test ideas and get feedback (Koster, 2004). In a game environment where game goals align with learning goals, learning can occur as the result of active interaction with the system.

Feature repayable, micro-content

Micro-content is particularly suited to the context of mobile learning. Ally (2005) supported that mobile learning should be "chunked" in small units of content in order to facilitate the learning process and found that 5-9 units per course are appropriate to compensate for human short-term memory. At the same time learning which is made up of small modular lessons, enables learners to make use of fragments of idle time for learning (Ronchettie & Trifonova, 2003) and therefore can be integrated in the busy schedule of lifelong learners competing against other distractions (Gu et al., 2011). Furthermore, content should be open-ended enough to be replayable (Fischer & Scharff, 1998), since retention can be affected by the amount of practice. Replayability is also enhanced via quick and simple interactions, while coupled with flexibility of access and engaging gameplay it is key to motivating learners to keep coming back.

Consider appropriateness

A mobile learning game should be appropriate for the circumstances of use of the given framework. The learning system therefore should be unobtrusive and persistent to manage learning through the learner's lifetime (Sharples, 2000). Additionally, accumulated data regarding the learner's knowledge should successfully transfer in the case of a device change and the learning environment and its modifications should remain up to date to be accessible via all devices supported (Sharples, 2000). The system should also be useful and intuitive (Dillard, 2012), to assist learners with various levels of familiarity with the device. Finally, the learning content should be appropriate to the subject matter and have practical, real-world application to the life of the learner (Knowles, 1998); this is important since adults need to see how the particular learning will assist them address a need, or life requirement.

Facilitate engagement

Similarly to traditional game-based learning, mobile learning games addressing adult learners should facilitate engagement. According to Ronchetti and Trifonova (2003) mobile learning should be engaging and entertaining, while Gu et al. (2011) propose that apart from engaging, mobile learning content should be well suited to everyday needs. Learner engagement can be enhanced via control, stimulation and interactivity, as well as adequate levels of challenge (Malone, 1980a). Challenge should be set high enough to engage but not as high as to cause frustration (Csikszentmihalyi, 1992). If the learning is not engaging enough and designed to match learner needs, the learner may choose not to interact or not to come back after the initial interaction.

5.1.2 Design Guidelines for Engaging Learning Games

One of the key benefits often attributed to game-based learning is the potential for learner engagement. It is therefore important to examine existing design guidelines for engaging game-based learning for the next stage of this review. Similarly as with the usability guidelines discussed on the previous sub-section, literature on designing engaging mobile game-based learning is scarce; it was therefore decided to look into

extant theory on game-based learning design for engagement and then its applications to the mobile context.

Some of the earliest and more influential work on engagement, has been conducted by Malone (1980a) via his investigation of the characteristics of games. Malone concentrated his work on game-based learning and looked into the use of engaging game characteristics to design enjoyable instructional systems. He originally presented three (3) game characteristics that lead to engagement which were challenge, fantasy and curiosity. Obviously according to the context, not all are necessarily equally compelling; for example in a mobile context it can be argued that fantasy is less compelling in comparison to challenge and curiosity. The additional characteristic of control was later added to the above (Malone & Lepper, 1987). Later on, Lepper (1998) also proposed a set of design principles able to promote intrinsic motivation for instruction and engagement with learning.

Prensky (2001) also highlighted the engaging powers of games, claiming they are potentially the most engaging pastime in the history of mankind. This is due to a combination of twelve (12) characteristics, which include fun and play as well as structural elements of games such as rules, outcomes, interactivity, feedback and challenge among others (Prensky, 2001, p. 106).

Another very influential theory, which can assist the understanding of engagement in game environments, is flow (Csikszentmihalyi, 1992). Flow describes a state of optimal balance between the challenge of the game and the skill of the player, where gameplay is considered to be neither too easy nor too difficult. This way an optimal experience is achieved, where players are so involved in an activity that they are totally engaged (Csikszentmihalyi, 1992). In a state of optimal flow the player allocates all his cognitive resources to the game, is fully emerged and enjoys the experience (Prensky, 2001). Flow theory summarises a number of elements that can increase engagement such as challenge in sync with player's skills, clear goals, immediate feedback, concentration and a sense of control, among others (Csikszentmihalyi, 1992).

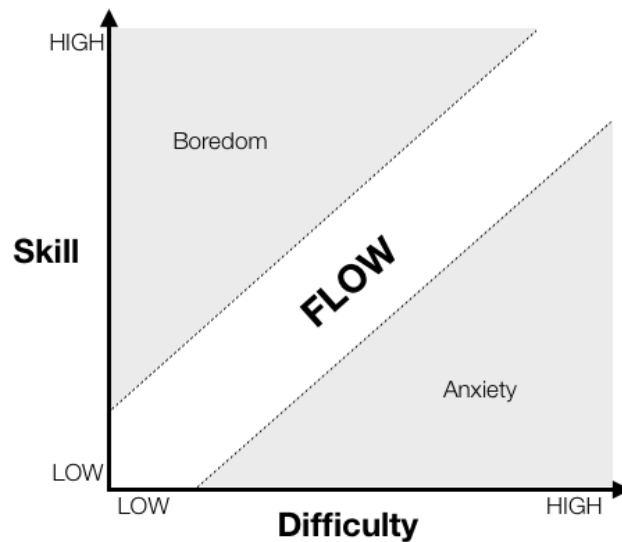


Figure 5-1: Flow (Csikszentmihalyi, 1992)

Clark (2007) discusses six (6) motivational characteristics of games, which can lead to engagement ranging from autonomy to self-confidence and challenge and proposes a user-centered experience. He suggests looking into game design to extract elements that can be applied to learning activities and increase the engagement of learners.

The principles discussed in the above literature, have been drawn together to form the following guidelines for designing engaging learning games:

The game should provide challenge

Games should provide a range of gradually introduced challenges increasing in difficulty, but also foster the feeling that the player can win the game (Csikszentmihalyi, 1992). An optimum balance between challenges, which are not too easy nor too difficult is important, in order to keep players engaged (Csikszentmihalyi, 1992). To ensure challenges remain appropriate to the skill level of the player either personalisation (e.g. choice over difficulty level) or adaptability (game adapting to the player's level of competence) could be built into the system. Variable outcomes relate to challenge, since the result of a game should not be immediately obvious and these can be increased via randomness, multiple levels of

goals, hidden information and via adjusting difficulty levels (Malone, 1982).

The game should provide feedback

Feedback is important to inform players about their competence in the game, as well as measure progress towards a goal (Prensky, 2001). Choices and consequences in the game can be evaluated via feedback and are particularly important in facilitating learning. Games are suitable to providing feedback as well as indicating player status in relation to a goal or a challenge (Clark, 2007). Feedback in games can take a variety of forms but should be meaningful and be given in an appropriate response time (Csikszentmihalyi, 1992). Providing feedback has strong emotional links that are key to the attraction of games (Prensky, 2001).

The game should foster interaction

Players are engaged by active participation rather than passive involvement in a game (Csikszentmihalyi, 1992). A highly interactive system provides a sense of control over both gameplay and interface and helps players see the effects of their actions and their progress (Malone & Lepper, 1987). Interactivity should be in sync with pace, which is in balance with the style of the game (e.g. a fast-paced game calls for fast paced interaction, while a game that requires thinking before making a move may call for slower paced interaction).

The game should promote stimulation

Mental stimulation can increase engagement and is achieved via diverse stimuli (Clark, 2007). Stimulation of sources or sensory curiosity can urge the player to make sense of information and situations, while stimulation of cognitive curiosity can enhance consistent understanding (Malone, 1980a). Humour (Malone, 1980a) and theme, can also promote stimulation. A meaningful storyline, or fantasy as Malone (1980a) describes, can also make the game more appealing. Where present, the story can be elaborated (e.g. a fully developed narrative in a detective game) or supplementary (e.g. simple backstory introducing the player to the game's context/theme) and relates to the type of game.

The game should be adaptable

In a learning context adaptability is important, since it can enhance engagement by making the game personally relevant to the player and increasing autonomy (Clark, 2007; Gabrielli et al., 2006). This is particularly applicable to the mobile context where devices are individually owned. Adaptability can increase the feeling of self-confidence and control that is key to engagement (Malone & Lepper, 1987). In a game-based learning context, adaptable games can monitor the player's progress and learning patterns and suggest personally relevant content.

5.1.3 Usability Guidelines for Mobile Game Interfaces

Usability is an important aspect of game development and characterises the ease of use and the ease of learning to use a game. Good usability can have a positive effect on the overall quality of a game and help create a compelling user experience. In short, usability refers to the ease of a system's use (Grudin, 1992) and can be defined by three measures including effectiveness, efficiency and satisfaction (ISO 9241-11, 1998).

Game heuristics on the other hand can be distinguished to two main kinds. These are *Positional Heuristics*, which evaluate the state of a game and indicate who is winning and *Directional Heuristics*, which tell the players what strategy to follow when playing the game (Elias et al., 2012). An example of positional heuristics would be to see how many cars are ahead in a race game and an example of directional heuristics would be to advise the player to run fast once the finish line becomes visible. These two types of heuristics generally support each other and playing well in a game involves using both kinds in conjunction (Elias et al., 2012). Such heuristics allow players to know if they are winning or losing as well as what to do next in the game and are important to make the game more enjoyable (Elias et al., 2012). Although good game heuristics are about gameplay richness and satisfaction however, they should also support game clarity and overall system user friendliness and this is where usability heuristics come into play.

Usability heuristics are sets or guidelines, based on established usability principles, designed to guide the design and assist the evaluation of the user interface of an application, or in this particular case a game. Heuristics are key for system design since they provide a clear understanding of the principles with which a design is build. Heuristic evaluations are an efficient, analytical and low-cost expert-based usability inspection method (Nielsen & Mack, 1994). Numerous usability heuristics are available in literature for the evaluation of video games (Clanton, 1998; Federoff, 2002; Desurvire et al., 2004; Pinelle et al., 2008), however work on universal usability heuristics for mobile games is still in very early stages. This is understandable considering the speed of innovation happening in the field, as well as the various systems and user interfaces available on mobile devices. At the same time, usability guidelines for mobile game-based learning are practically non-existent.

Perhaps the most widely referenced and used usability heuristics are Jakob Nielsen's ten (10) heuristics for software design (Nielsen, 1994). Although these heuristics are not targeted specifically at games since they are intended to be used for the evaluation of software interfaces by Human Computer Interaction (HCI) professionals, they are still applicable to the design of game interfaces.

However usability issues for game interfaces are not necessarily the same as in other software, since gameplay issues need to also be taken into consideration when discussing usability heuristics for games. According to Desurvire and colleagues (2004) playability is the ease with which the gamer learns, uses and masters the game. Playability should be in the core of game heuristics and so game designers should go beyond an evaluation of the interface and consider aspects of gameplay and mechanics as well. Malone (1980a, 1982) was the first to introduce the idea of using heuristics to evaluate games. Interestingly enough, he proposed a set of heuristics for designing enjoyable interfaces, primarily based on the study of educational games. Chuck Clanton (1998) proposed three areas of consideration with regards to the usability issues found in games, including: *Game Interface*, which is

the device through which players interact with the game; *Game Mechanics*, which are the physics of the game; and *Game Play*, which is the process followed by the players in order to reach a goal in the game. He then proposed a set of thirty (30) heuristics that addressed engaging game design, based on these three areas. Later on in 2002, Federoff assessed the applicability of Nielsen's heuristics to the area of computer games and developed a set of forty (40) usability guidelines for computer game design, partly based on Nielsen and partly on game experts' input. She categorised these guidelines into game interface, game mechanics and gameplay, the three design areas previously proposed by Clanton, identifying specific heuristics problems in games (Federoff, 2002). Other interesting work in the area includes a set of verified heuristics for the evaluation of playability (Desurvire et al., 2004) and a set of heuristics based on game reviews (Pinelle et al., 2008).

Although various playability heuristics exist for the design and evaluation of computer games, when investigating games playable on mobile devices additional usability requirements need to be addressed to comply with the requirements of the platform and the context of use. Recognising that the mobile gaming context has specific characteristics that require special attention, Korhonen and Koivisto (2006) introduced playability heuristics for mobile games. Their model presented twenty-nine (29) heuristics divided in three modules including game usability, gameplay and mobility. The heuristics can be used to guide the design of most mobile games, however the initial model does not cover games with additional characteristics such as multiplayer and social or pervasive games. More recently a set of heuristics for mobile games has been proposed, based on analysis between a computer game's heuristics and a mobile game's heuristics comparison (Soomro, Ahmad & Sulaiman, 2012); ten (10) mobile games heuristics were identified, four (4) of which were targeted at multiplayer games. As mentioned at the beginning of this sub-section, heuristics for mobile learning games are practically non-existent, however Zaibon and Shiratuddin (2010) have proposed an evaluation strategy targeted at mobile game-based learning, heavily based on the playability heuristics for mobile games introduced by Korhonen and Koivisto (2006) but extending them to include four (4) learning content related guidelines.

The key design principles drawn out of the heuristics described in the above paragraphs have been synthesised in the following set of guidelines, aiming to inform the development of usable interfaces for mobile learning games:

The game should fit multiple contexts

Contexts of use for mobile games vary since environmental conditions can dynamically change for a user on the go. Mobile games can be used indoors and outdoors and therefore under different lighting conditions; it is therefore advisable that high colour contrast is used in design (Koivisto & Korhonen, 2006). Furthermore, the font size should be such as to allow comfortable reading in indoor and outdoor spaces (Koivisto & Korhonen, 2006). At the same time, although sound and music can enhance immersion, it is preferable for mobile games not to rely on audio and for the game not to rely on sound feedback but rather it should be possible to keep playing while on mute (Koivisto & Korhonen, 2006). The same is true for spoken input, especially in contexts where sound is restricted. In addition, games playable with one instead of two hands are preferable, since they can support gameplay in various conditions where the user may have one hand occupied (Koivisto & Korhonen, 2006).

The screen layout should be efficient, uncrowded and pleasing

An efficient screen layout should present all necessary information and indicate the most important elements as well as how those elements relate to each other (Federoff, 2002). Presenting all essential game information, while at the same time avoiding a crowded layout, requires special attention in a mobile context due to the smaller size of the screen (Koivisto & Korhonen, 2006). The designer should therefore keep required information to a minimum and make sure it is always visible (Nielsen, 1994). If a free orientation is going to be allowed then the screen layout should be dynamically customised to remain efficient, uncrowded and pleasing (Koivisto & Korhonen, 2006). To achieve better immersion it is recommended that the game runs in full-screen mode and hides other device features (Koivisto & Korhonen, 2006). Finally consistency is key (Nielsen, 1994), so when the game is designed to be playable across multiple devices (e.g. phone and tablet) the screen

layout should remain consistent between them.

Game controls should be intuitive and minimalist

Game controls should be intuitive, consistent and logical (Nielsen, 1994). At the same time navigation should also be minimalist and logical (Desurvire et al., 2004) and navigation paths should remain short (Koivisto & Korhonen, 2006). Furthermore, easy access to the home screen/main menu of the game should always be provided (Koivisto & Korhonen, 2006). Finally, controls should not allow for critical errors and eliminate error-prone conditions (Nielsen, 1994). Game controls and navigation should remain consistent across mini-games/levels where these are used, as well as across devices.

The game should be responsive

The game should be responsive to user input and the response time should be short (Nielsen, 1994). If a delay in response time is anticipated due to technical constraints the game should notify the player (e.g. using a loading screen) (Clanton, 1998). Feedback should be provided to indicate that the system has recognised input (Nielsen, 1994). This feedback should be meaningful to the player and be provided in appropriate time (Desurvire et al., 2004). In line with the first guideline (*'The game should fit multiple contexts.'*) feedback should preferably be visual instead of auditory to allow play in multiple contexts (Koivisto & Korhonen, 2006). Finally, it should be clear when the game has ended and allow for replay.

Game goals and progress towards them should be clear

Games are packed with strategic and tactical goals, which are key to fostering engagement and a sense of achievement (Malone, 1980a). The goals of the game, whether short or long term, should be clear to the player (Desurvire et al., 2004). Short-term goals should be easier to achieve than long-term ones, and help foster motivation towards the achievement of a larger goal (Federoff, 2002). According to the type of game and outcome, player driven goals could be provided (Koivisto & Korhonen, 2006). At the same time the player should be able to clearly see the progress towards a goal and compare this progress to that of other players or towards

game achievements (Koivisto & Korhonen, 2006).

The player should feel in control

Players want to feel in control and have the system interact to their actions (Desurvire et al., 2004). Therefore, players should be able to make decisions on actions to be made in the game and see how these actions affect the gameplay (Desurvire et al., 2004; Pinelle et al., 2008). Additionally quick recovery from errors should be provided for interface interactions (e.g. return to main menu after choosing a non desirable level) (Nielsen, 1994), while trial and error should be supported for gameplay (e.g. fine-tune play strategy after trial and realisation of how an action affected gameplay). At the same time, the game should allow customisation to increase the feeling of ownership (Koivisto & Korhonen, 2006). Finally, the player should be able to easily go out of gameplay mode and return to the game state he/she was in, when gameplay was interrupted (Koivisto & Korhonen, 2006).

5.1.4 Game Design Guidelines for the Mobile Platform

In this final sub-section, mobile game design is discussed. Game design for the mobile platform has its own unique characteristics and it is thus necessary to explore specific affordances when creating games playable on mobile phones and tablets. In order to develop content that is truly device specific and facilitates an appropriate user experience the features of the platform need to be explored. According to Unger & Novak (2012) the best approach to mobile game design is to evaluate the affordances it offers and prototype according to them, instead of forcing existing gaming conventions from other platforms to fit the mobile context.

One of the initial considerations in mobile game design is the screen size of devices, which is considerably smaller in comparison to other platforms such as PCs and can have an important effect on gameplay and UI design. A common misconception is that game design for mobile devices is easier because of the smaller screen but this is not the case, since it requires a novel way of thinking about content and gameplay.

When creating content for the mobile, the designer has to consider screen layout, scaling and user interface arrangements so as to provide all the necessary information about the game without overcrowding the screen. There are certain game genres, such as puzzles that naturally scale down but for others like role-playing games, which require a larger area of play there are some challenges to address in a mobile context (Unger & Novak, 2012). In the case of role-playing games for example, a solution to the size of the screen would be to display less of the play field at a time and allow window scrolling to reveal the total play field (Scolastici & Nolte, 2013).

It is important to remember that mobile games should not require complex controls. This is not only for usability purposes, as discussed previously on this chapter, but also for efficiency due to processing power and the overall screen real estate. Adding virtual control buttons tends to overcrowd the game interface and use up the limited screen space. Exploiting the interaction opportunities of touch screens such as tapping and dragging, a game designer can make the most out of the mobile user experience and user interface (Scolastici & Nolte, 2013). The chosen control scheme should also be consistent amongst supported devices, or at least adjusted to a limited degree for each device (Unger & Novak, 2012). Finally, file size is still something that needs to be taken into consideration by game designers to allow for easy download and fast processing of the game in real time.

Equally important to interface considerations are gameplay considerations that have to do with play behaviours and circumstances of use. “Mobile games address a fast-moving mind-set” (Unger & Novak, 2012, p.106) and can be played anywhere and at any time, so they should ideally be easy to pick up, flexible and offer short play sessions that can be interrupted and resumed. An average mobile gameplay session will usually last for a few minutes, since mobile games are short-form by nature (Unger & Novak, 2012). Mobile gameplay sessions tend to be quick, featuring short-term reward cycles and lower game depth.

Furthermore, mobile games should be accessible and immediately playable. Players should preferably be able to start a play session in less than 5 sec (Koivisto & Korhonen, 2006). Accessibility is supported by simple controls, gesture based interfaces and overall user-friendliness and learnability. The need for tutorials is minimised in this context, however when training is required the best approach is to be embedded into gameplay. Overall mobile simplification in comparison to games playable on other contexts however, does not imply non-challenging games. “Easy to pick up and hard to master” has become the golden catchphrase in mobile, as players are drawn to games that challenge them without demanding a long time commitment or complex controls (Unger & Novak, 2012, p. 107).

An additional key consideration for mobile game design is the flexibility of gameplay. Flexibility and interruptibility are important reasons that explain why the mobile platform lends itself to shorted bursts of play. Mobile games are playable on mobile devices, which are multipurpose devices not exclusively used for gaming (Koivisto & Korhonen, 2006); this means that naturally, gameplay will often be interrupted. The game should therefore be easily paused and auto saved, to allow players to return to it. According to Unger and Novak: “Longer play sessions with checkpoints, such as those used in console shooter games are not as viable in mobile games as having shorter levels or automatic saves during interruptions so that the player can drop back in at any time” (2012, p. 107). Since mobile devices are personally owned and highly individualised, flexibility may also extend to personalisation; in this case player settings should be saved and recalled every time the player returns to the game.

A successful characteristic of popular mobile games is their ability to provide positive and rewarding gameplay experiences. In comparison to games playable on other devices, which require longer play sessions to provide reward, mobile games tend to feature short reward cycles. Facilitating an encouraging first time experience for novice players as well as meaningful rewards is important for mobile game design (Koivisto & Korhonen, 2006). Considering many popular mobile games, such as ‘Angry Birds’, ‘Hay Day’, ‘Cut the Rope’, ‘Bejewelled’, etc. one can realise that

they tend to feature positive, enjoyable, cartoony and ‘lighter’ themes that lend themselves to vibrant and pleasant game settings. Short reward cycles combined with highly responsive environments are characterised by game designer Kyle Gabler as “juiciness” and can make players feel in control, coaching them in the game and letting them know how they are doing (Gabler et al., 2005).

Finally, appropriate visual design is a key consideration for mobile games. The use of smart colour schemes is important to make elements like enemies, obstacles and the background of the game easily recognisable (Scolastici & Nolte, 2013). Consider ‘Angry Birds’ where protagonists are created with primary colours such as red, blue and yellow and enemies with the secondary colour green (Rogers, 2012). Game characters especially, require additional consideration in a mobile context due to size and level of detail. Mobile screens are generally smaller and players need to be able to tell the difference between game elements therefore colours, shapes, silhouettes and the size of elements is important (Rogers, 2012). According to (Unger & Novak, 2012, p.108): “One of the reasons the ‘bubblehead’ or ‘chibi’ look for mobile game characters is so popular is that it allows for a clearly recognisable face on a character that is often around 34px tall”. With regards to game graphics both 2D and 3D are available for mobile, although most popular games appear to be 2D.

The key mobile game design considerations discussed in the above paragraphs have been drawn together to the following set of guidelines, aiming to inform the design of device-specific mobile learning games:

Design for the mobile interface

Mobile devices have their own interfaces that require reconsideration of established game design practises, posing challenges but also providing opportunities for innovative gameplay (Unger & Novak, 2012). The smaller screen has an effect on gameplay and UI design and requires special attention since the game screen should allow for all the necessary information to be visible and identifiable (Koivisto & Korhonen, 2006). Additionally, graphics and user interface assets should be optimised for mobile and designed separately for each main mobile screen resolution

supported, to ensure consistency and visual quality between devices (relying on automatic resizing and scaling does not usually work well) (Unger & Novak, 2012). At the same time, using up the screen space with virtual control buttons should be avoided (Scolastici & Nolte, 2013) and alternative mobile specific controls such as touch screen input and sensors (e.g. the accelerometer) should be preferred (Unger & Novak, 2012). Therefore the aim should be the implementation of simple controls that feel intuitive, match the context and do not affect the gameplay area.

Gameplay should be designed around shorter play sessions

In a mobile gaming context the player should be able to have an enjoyable experience in a few minutes, since mobile games are short-form by nature (Unger & Novak, 2012). Considering play behaviours game designers should allow for quick play sessions in order to provide short, dedicated bursts of play (Unger & Novak, 2012). To achieve that, mobile games should have short reward cycles and be primarily based around short-term goals, without excluding long-term ones that may be more difficult to reach (Koivisto & Korhonen, 2006). Ideally the player should feel a sense of completion every few minutes. Due to shorter play sessions, a lower game depth, which demands minimal time commitment, is appropriate (Scolastici & Nolte, 2013).

The game should be easy to pick up and play

Mobile game experiences should be easily accessible (Koivisto & Korhonen, 2006). The player should be able to jump in the game and play anytime and in order to allow for pick up and play, mobile games should have a short learning curve (Unger & Novak, 2012). A short tutorial could be provided as part of the game, however it should ideally not be necessary as the game should intuitively teach the player what is required in order to play without the need for training (Koivisto & Korhonen, 2006). Gradual on-boarding (see Glossary) and gradual increase of the level of difficulty is the most effective way to enhance the learnability of mobile games (Koivisto & Korhonen, 2006). Therefore the game should be easy to access and quick to start in order to allow for effective pick up and play (Unger & Novak, 2012).

Flexibility is key

Mobile games are playable on multitask devices that are not exclusively used for gaming (Unger & Novak, 2012). Especially when it comes to mobile phones, gameplay should be flexible and highly interruptible since unexpected events ranging from phone calls to notifications and automatic updates may interrupt a play session anytime (Koivisto & Korhonen, 2006). Additionally, since games are often played on the go and in various contexts the player should be able to easily stop the game anytime without losing progress; build in pause and auto save should therefore be implemented (Unger & Novak, 2012). To remain accessible but also challenging enough to retain engagement, a game should allow variable levels of difficulty or better yet be adaptable to the skill level of the player.

The game should be positive and rewarding

The consideration of reward in gameplay is an important one for mobile game design. Reward cycles should be short and provide incentive that is meaningful and analogous to the challenge (Koivisto & Korhonen, 2006). Positive feedback can be incorporated in gameplay in various ways (Gabler et al., 2005) and it should be used to encourage players along with providing them with the appropriate reward for their efforts (Scolastici & Nolte, 2013). In addition, the first interaction for novice players should be encouraging in order to drive the player to come back to the game and not be easily discouraged (Koivisto & Korhonen, 2006). Reward does not imply an overly easy and unchallenging gameplay, but rather that rewarding the player is more effective for enhancing engagement, providing a positive play experience and so it should be preferred to punishing mechanics (Unger & Novak, 2012). This way feelings of control and competence are enhanced and positive reinforcement is facilitated.

Visual design should be appropriate

Visual representations, including characters, props and secondary elements should be recognisable and easy to interpret (Scolastici & Nolte, 2013). Overall, the visual design should help the player distinguish between primary and secondary elements as well as between active and purely stylistic graphics (Rogers, 2012). Visual style

and colour schemes should be carefully selected, to allow for appealing, aesthetically pleasing and meaningful environments (Karlsson & Djabri, 2001). At the same time, visuals should be uncluttered and consistently placed between screens (Koivisto & Korhonen, 2006). Finally, visual style should remain consistent for game elements (e.g. loading screens, typography, dialogue boxes, menus, etc.).

The above game design guidelines have been brought together with the ones discussed in the previous subsections, to inform the development of the four sets of final design guidelines for mobile game-based learning as described on the final section of this chapter.

The following section supplements the guidelines synthesised from the literature and examines a number of case studies to investigate their interface and gameplay characteristics, which could potentially enhance engagement.

5.2 Case Studies Review

Alongside with analysing existing literature to advance design guidelines for mobile game-based learning as described in the previous section of this chapter, it was considered important to conduct a review of existing mobile games. The aim of the review was to extend the design guidelines and to allow the researcher to gain a first-hand understanding of components of good design of popular mobile games via exploring elements of their interface design. More specifically, there were three main aims for the review of the case studies. First, to overview the types of popular mobile games currently available. Then, to examine possible design elements and game design patterns that contributed to their usability and appeal to a wide range of users and made them easy to use and engaging. And finally to identify design elements to inform the development of a game prototype, which was the next stage of this research.

This review was intended to examine a relatively large number of mobile games quickly, rather than to focus on in-depth analysis of a small number of case studies. This method was considered suitable not only for the research needs but also for the context, due to the nature of mobile games which allow for short play sessions, are not time consuming to set up, and are inexpensive. Such games can be easily downloaded using a mobile device (smartphone or tablet) and used immediately. Additionally, mobile games are usually quick to play, while there is a large number of games available and a wide variety of genres, styles, gameplay types and themes. Furthermore, these games are easy to learn and therefore there is no need for time consumption on extensive tutorials. For all the above reasons a relatively large number of games could be acquired, accessed and play tested for this review.

Since one of the main aims was to review mobile games that were popular among users at the time the review took place (early 2013), and the device available to the researcher at the time was the iPhone 4S, the Apple App Store was used to access and download games. The App Store provided rating systems as well as top chart systems useful to identify popular mobile games. Therefore the decision on which games to examine was informed partly by these rating systems, but also by the researcher's own understanding and finally from reviews (games that were the subject of large amount of discussion both official and unofficial). Finally, the decision was also influenced by the results of the background study, as described on the previous chapter. 'Angry Birds', 'Bejeweled', 'Cut the Rope', 'Plants VS Zombies' and 'Tetris' as well as various other word puzzle games such as 'Bookworm' were amongst the most frequently mentioned among survey participants. Therefore the aforementioned games became the six out of the eight case studies finally selected. Popularity was an important factor when selecting which games to review since the aim was to select cases that could potentially maximise what could be learned, via maximised engagement.

Originally, twenty (20) games were examined and eight (8) were selected for further review based on various criteria, including: popularity (to ensure wide appeal as well as relevance to the current state of the art of mobile game design), variety of genres (to allow for a wider understanding and an array of different characteristics), single-player or offering a single-player mode (to limit complexity and avoid introducing a level of social play which would add additional variables to interface design and engagement) and with no obvious errors or malfunctions. The games that were finally selected as case studies for review were the following: ‘Angry Birds’, ‘Plants VS Zombies’, ‘Hay Day’, ‘Bejeweled’, ‘Bookworm’, ‘Tetris’, ‘Dinner Dash’ and ‘Cut the Rope’.

Overall, case studies are oriented towards the case, which can be explained as “a unit of human activity embedded in the real world” (Gillham, 2000, p.1). Here, cases refer to mobile games and as such they need to be investigated to gather data, which will act as evidence that allow possible answers to a research question (evidence are there in the case but need to be abstracted and collected) (Gillham, 2000, p.1-2). However in this particular research, case studies play a supportive role and along with the data collected by the review of extant theory on mobile learning design, engaging game-based learning, usability and mobile game design, they informed the development of a set of design guidelines to support mobile game-based learning.

According to the review methodology adopted, the researcher played every game for a minimum of 30min to 1hour before noting areas for further discussion. This play testing time allowed for familiarisation with the game and its interface as well as some adequate level of comfort with gameplay and controls. Games were initially reviewed in relation to the design guidelines proposed in the previous section and then considered again to identify additional elements of design appealing to the researcher, not otherwise covered by the design guidelines. The aim was to identify design elements, which contributed to engagement and then examine whether these were possibly shared amongst cases studies. If identified, such additional design elements could then be utilised to extend the existing guidelines.

Although the views expressed regarding appealing game characteristics are the opinions of the researcher as a single person, this part of the research was aimed to extend and support the review of extant theory discussed on the previous section and is not discretely used. Additionally the researcher's design background coupled with considerable game design experience could be seen as beneficial when identifying appealing gameplay elements.

The second step of the review was to consider the case studies again, this time in relation to a solid structural framework for the analysis and design of games, which was the Game Design Patterns model developed by Bjork and Holopainen (2004). This step was meant to complement the critical interpretation of engaging game design elements previously conducted by the researcher. The aim was to identify game design patterns featured in each case and examine whether these patterns were shared amongst the cases. The Game Design Patterns model used here is a framework for the study of games, which can be utilised to describe their components and patterns of interaction and how these can affect various aspects of gameplay (Bjork & Holopainen, 2004). Bjork and Holopainen (2004) recognise that these patterns are primarily meant as problem-solving tools however they do not propose one single method for using them. Amongst the possible methods proposed, patterns could provide a simple way to start analysis existing games by simply going through the collection to see if a pattern exists in a game (Bjork & Holopainen, 2004). Assuming that a patterns-based review has been performed on a collection of games, which is the case here, these can then be categorised by their similarities.

Following, the selected cases are discussed in terms of the attributes that make them engaging as well as the game design patterns they feature, based on the model developed by Bjork & Holopainen (2004). Then, elements of appealing design identified are presented at the end of the section for each case.

5.2.1 Angry Birds

‘Angry Birds’ (Rovio Entertainment, 2009) is a popular puzzle mobile game which involves using a slingshot to shoot birds acting as cannon balls, to houses made by various materials like glass, timber and rocks and populated by green pigs. The aim is to completely demolish the houses using as few birds as possible. The more damage the player does using a certain amount of birds, the more points are awarded. Additionally there is a backstory element, which introduces a simple game plot and provides some context on the anger of the birds towards the pigs, which repeatedly attempt to steal and cook the birds’ eggs.

Pick up and Play

One of the main strengths of the game when it comes to engagement is the fact that the user interface is simple and intuitive. Even from the first interaction with the system controls, scoring and goals become easily understandable in a brief period of experiencing the game. However, a simple to understand and to use game doesn’t necessarily facilitate engagement. In the case of ‘Angry Birds’ this is achieved by balancing the user’s understanding of the system with skill development. As the game progresses and complexity layers are added to the gameplay the user’s original understanding of the game expands, thus making it possible to facilitate flow.

One of the game design patterns ‘Angry Birds’ successfully facilitates is a *Smooth Learning Curve*, by providing players with the possibility of smoothly progressing from novice to master and by adjusting the difficulty of challenges to player skills (Bjork & Holopainen, 2004). Coupled with clear goals, a *Smooth Learning Curve* can ensure that players face the *Right Level of Difficulty* whatever their skill level, thereby providing them a *Perceived Chance to Succeed*, which increases the feeling of control. Accessibility is also enhanced by the *Right Level of Complexity*, achieved by initially allowing a *Limited Set of Actions* and gradually introducing *New Abilities* via the addition of complexity layers while the skill of the player builds up.

Positive Reinforcement

One of the main features of ‘Angry Birds’, which can enhance engagement and is common in mobile games is positive reinforcement. Positive reinforcement is mainly facilitated via score and game rewards, while punishment is minimised. In ‘Angry Birds’, apart from a pigs’ mocking laughter sound effect, there is not really any other punishment for not completing a level successfully (e.g. subtracting points or losing lives). The player either wins the level or loses and replays. To motivate replay, even when the level is successfully completed, there is also a star system featured at the end of each level monitoring user performance. This mechanic may positively encourage replay until reaching the excellent three star score.

Rewards are a common game design pattern, according to which players receive something perceived as positive for completing the goals of the game; this is usually a change to the game state (e.g. score, three stars), or a game-related effect that makes other goals easier to complete (Bjork & Holopainen, 2004). In ‘Angry Birds’, *Illusory Rewards* are also featured, which do not quantifiably help in completing a formalised goal, but are still perceived as rewards by the players (e.g. cheering sounds, when a level is successfully completed). *Score* is also featured in the game, since points are awarded for good performance.

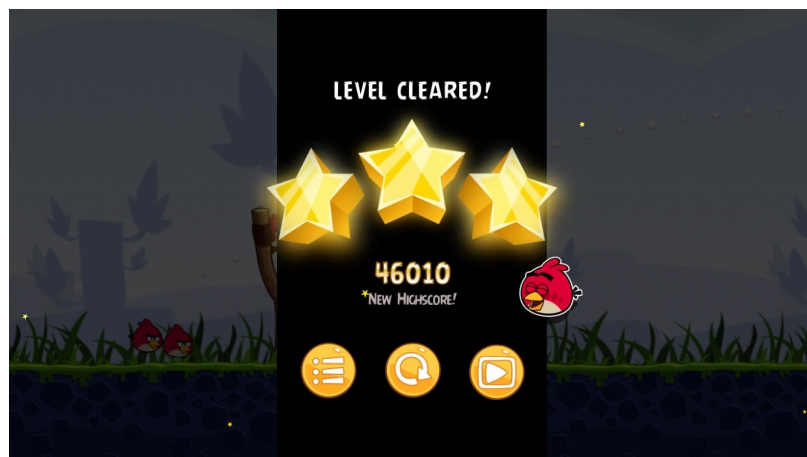


Figure 5-2: Three stars awarded at the end of the level (Rovio Entertainment, 2009)

Improve Performance via Trial and Error

Another engaging element of the game is that it allows players to learn from own mistakes and gradually build up skills when it comes to throwing bird bombs to pig houses. Every time a bird is thrown, a line marks its flight across the sky allowing the player to see how the height and angle of the throw affected the landing of the bird on the building. Therefore the user can gradually correct bird throws to achieve better hits via trial and error. This way, the player may gradually improve own performance. Systems that help players build their skills, can empower and motivate them and have interesting potential, especially for educational games.

As previously mentioned, 'Angry Birds' facilitates the game design pattern of a *Smooth Learning Curve*, since it supports players in developing their skills. The gradual development of bird throwing skills via trial and error is thus supported by *Experimenting*, according to which actions are performed to learn how the rules or cause and effect work in the game (Bjork & Holopainen, 2004). Furthermore, it can increase players' feelings of *Empowerment* and gradually lead to *Game Mastery*, when players feel that they have a clear understanding of the game and their skill level is sufficient for the challenges presented.

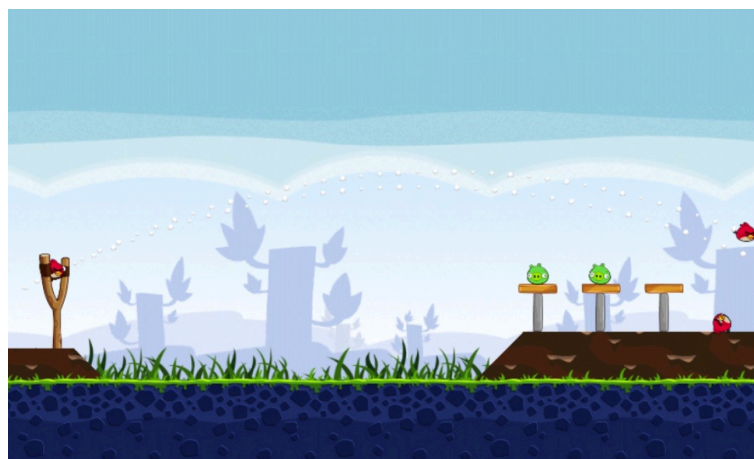


Figure 5-3: Bird throw trajectories are visible across the screen (Rovio Entertainment, 2009)

‘Peek’ and Strategize

Whenever a new ‘Angry Birds’ level begins, the screen automatically slides to the right to reveal the building housing the pigs and then the camera slides back to the left of the screen where the birds line up. This allows for a quick peek at the ‘enemy front’ and helps the user start strategizing. Via this mechanics a level of complexity is added to the game, as the player will need to remember what was revealed. This dynamic motion of the camera adds a level of interactivity requiring some better-calculated bird throws for the more advanced users.

A game design pattern used successfully here is *Tradeoffs*, which refers to the choices players have to make between options, comparing values against each other (Bjork & Holopainen, 2004). In ‘Angry Birds’ tradeoffs have to do with the types of throws the player will decide to go for, according to the type of bird available to throw, in order to maximise damage. This is here linked with *Memorizing*, since the player benefits by remembering the structure of the building housing the pigs, which will maximise the value of the throws.

Visual Design Appropriate

The game’s visual design is cartoon-like, clean and sharp, with a hint of humour which can be appealing to adult audiences. The game world is two-dimensional, while its design is simplified, yet detailed enough to be visually engaging. Visual variation is present with many well-designed and different looking game levels, which help avoid repetition. Overall, the design is memorable and works well with the elements of the gameplay model.

In ‘Angry Birds’ the *Game World*, which is the environment in which the gameplay takes place (Bjork & Holopainen, 2004), is 2D meaning that movement is limited to a two-dimensional plane. Furthermore, two-dimensionality is not limited on player movement and expands on graphical representations, since the design features 2D flat graphics and 2D layers of visual depth. The game successfully features

Consistent Reality Logic in its visual design, since all graphical elements are aesthetically coherent and stylistically appear to be parts of the same world. *Consistent Reality Logic* is also expanded to the game metaphors that represent natural ways of being in the real world. For example, the representation of bird throws in the game logic convincingly mimics physical laws of the real world.

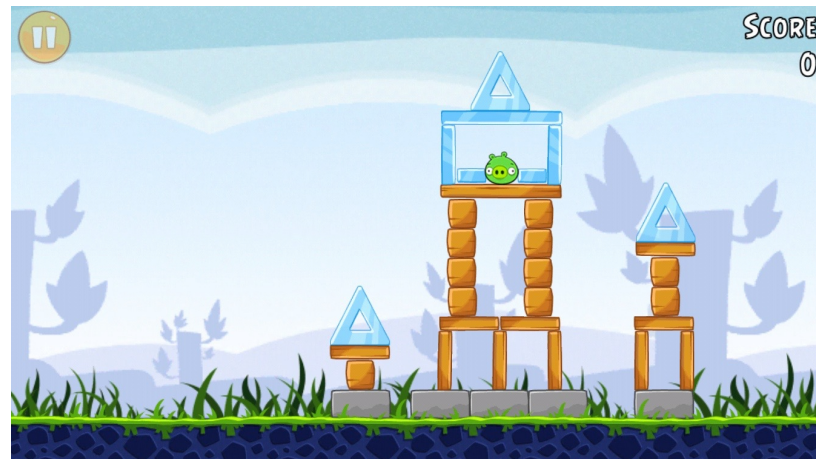


Figure 5-4: Cartoon-like, clean and sharp 2D design (Rovio Entertainment, 2009)

The following table summarises the prominent characteristics of ‘Angry Birds’ extracted from the above discussion:

The user interface is simple and intuitive
Goals become understandable in a brief period of experiencing the system
Complexity layers are added as the user’s understanding of the system expands
Reward is maximised and punishment is minimised in the game
The game guides players on improving performance
Multiple play-throughs are encouraged and level replay facilitated via star system
Clean, sharp, cartoonish characters are used with a bit of humour

Table 5-1: ‘Angry Birds’ most prominent mobile game design characteristics

5.2.2 Plants VS Zombies

‘Plants VS Zombies’ (PopCap, 2010) is a strategy mobile game. In this game the user has to defend his house against brain eating zombies marching towards it. The front yard lawn, the house pool, or the roof of the house act as the last line of defence against the attack. This is where the user has to strategically plant different types of plants that shoot peas to the zombies, act as traps or walls and help stop the onslaught. The ground where the action takes place is divided into six rows and zombies march towards the house following random paths, however they can only move forward and do not cross over from path to path. Once they reach a plant they fight it until it disappears. Zombies may come toward the house in multiple bodies and from time to time there are waves coming at the same time. The game features a variety of different plants and different zombies, each with its own capabilities. As the game progresses and new levels are unlocked, more plants become available and at the same time stronger zombies are added to the attacks.

Game Pacing

In game design, pacing refers to the overall rhythm of a game. Pacing is important for engagement because in the case of unbalanced pacing, the user may feel frustrated either because the game is too fast or too slow. Even pacing is often achieved via game patterns, meaning repeated behaviours or responses to actions. However there is a trade-off with using patterns since when all patterns are identified the game may become uninteresting. An optimal balance therefore needs to be achieved between keeping gameplay patterns even and still making sure that the gameplay remains challenging. A relatively straightforward way to achieve this balance is by modifying the non-core mechanic in a constant rhythm to increase variation.

In ‘Plants VS Zombies’ the *Varied Gameplay* design pattern, which refers to variations either within a single play session or between different play sessions (Bjork & Holopainen, 2004), is achieved via a pattern break with the introduction of a unique mini-game after five subsequent game levels. In each of those unique mini-

games, the core activity of defending the house against the zombies remains the same, however the method of defence changes. For example, in one of the mini-games the player uses a hummer against the zombies while in another, rolling walnuts in a bowling type game field (see Figure 5-5). Furthermore, *Varied Gameplay* is also achieved visually, via scenery changes (e.g. front garden, back yard, house roof etc.).



Figure 5-5: Breaking the main gameplay pattern via a bowling mini-game (PopCap, 2010)

Feature Adding

‘Plants VS Zombies’ features many types of plants and zombies. The game begins with simple production and defence plants and one type of zombie but new plants and new zombies are quickly unlocked. This feature adding system can successfully be used in games to ease players in and gradually introduce added levels of difficulty, especially relevant to strategy games (stronger zombies require more powerful plants and a well thought out defence strategy). This additive pattern is retained throughout the game in ‘Plants VS Zombies’, however to limit the scope and avoid overwhelming the player, the number of plants and zombies featured in each level is restricted. For every level the user can choose up to a certain amount of plants to play with.

Introducing new gameplay features can assist a *Varied Gameplay*, which can increase player interest. More importantly however, gradual feature adding can facilitate a *Right Level of Complexity*, which ensures that the overall complexity of the game is in sync with the player skill and is the one intended by the game design (Bjork & Holopainen, 2004). The *Right Level of Complexity*, can be supported by initially allowing a *Limited Set of Actions* in the game (here a limited set of plants and zombies), and gradually introducing *New Abilities* via the addition of complexity layers, which can also assist a *Smooth Learning Curve*. Furthermore, it can increase players' feelings of *Empowerment*, easing them in and gradually leading them towards *Game Mastery* when the skill level is sufficient to face added levels of difficulty.

Strategic Planning

The game cleverly facilitates strategic planning in the use of the feature adding system described above. At the start of each level the camera floats to the right of the screen and allows the user to see the zombies standing outside the garden, ready to attack. This view is not visible in the actual game since the camera moves back to show the house and the lawn where the action takes place. Not knowing the exact order in which the zombies will attack, adds an element of mystery and a surprise factor. However, by revealing the types of zombies about to attack at the beginning of each level, the game allows the player to make an informed decision on the types of plants to choose to play with since each plant is best suited to fight zombies with certain capabilities. Since the player has a limited amount of slots and can choose to play with a set amount of plants, strategic thinking is required. Picking the right plants is half the battle, and this means that the player has to customise his strategy to win.

A game design pattern used successfully here is *Tradeoffs*, according to which players have to choose between options during gameplay, comparing values against each other (Bjork & Holopainen, 2004). In 'Plants VS Zombies' tradeoffs are about choosing the right type of plants to play with, thus informing *Strategic Knowledge*.

There is also an element of *Memorizing*, since the player needs to remember the types of zombies standing outside of the garden after the camera moves back to the right of the screen, and plan defences accordingly. Since specific types of plants are more effective against specific types of zombies *Experimenting* is supported, according to which actions are performed to learn how cause and effect work in the game (Bjork & Holopainen, 2004). *Experimenting* and *Tradeoffs* are linked to *Freedom of Choice*, since players can make choices and see how these will affect the progress and outcomes of the game.



Figure 5-6: Zombies standing outside the garden (PopCap, 2010)

Back Story

Another interesting game element, which can enhance engagement, is the backstory. Even a simple back-story can often help provide the user with some context, explain game goals and assist immersion. In ‘Plants VS Zombies’ the way the backstory is communicated is via a character named ‘Crazy Dave’. He is the crazy neighbour who knows all about the zombies and advises the player. The method of communication is text bubbles and ‘Crazy Dave’ will return every couple of levels to introduce a mini-game or a scenery change. The way the character introduces levels is via short stories, which help players understand the drives of the actions of the zombies. An additional story element is the letters that zombies send to the player every few levels, which provide warnings on upcoming attacks.

The main game design pattern here relates to unfolding the underlining story of the game world and is *Narrative Structures*, which gives players motivation upcoming challenges in the game (Bjork & Holopainen, 2004). In ‘Plants VS Zombies’, *Narrative Structures* explain changes in the game world, provide warnings or explain players’ goals and appear in the form of *Cut Scenes*. Cut Scenes are sequences of storytelling where players cannot act within the game and are usually located right before a challenge (‘Crazy Dave’ communicates via text bubbles) or right after the end of a level (letters from zombies).



Figure 5-7: Crazy Dave welcomes player (PopCap, 2010)

The following table summarises the most prominent characteristics of ‘Plants VS Zombies’ as discussed in the above game review:

The game pace is balanced (not too fast, not too slow)
Gameplay patterns are consistently changed to allow variation
The game makes use of gradual feature adding
The game allows for strategic planning
Goals and resources are revealed before the player decides on gameplay strategy
Incorporate short tutorials in the game back-story
Break down the backstory in sections and intervene between levels
Clean, sharp, cartoonish characters are used with a bit of humour

Table 5-2: ‘Plants VS Zombies’ most prominent mobile game design characteristics

5.2.3 Hay Day

One of the most popular mobile farming games is ‘Hay Day’ (Supercell, 2012). Farming games, which are often discussed as a genre of their own have been very popular on the web the past few years and they have been now also migrated on mobile devices. In ‘Hay Day’ the user manages a farm while the gameplay involves producing, harvesting and trading various goods as well as gradually building up and decorating the farm. The concept overall feels simple at first, however the game quickly becomes addictive, bringing an interesting twist to classic farming games.

Context Specificity

‘Hay Day’ is context specific. One of the main benefits of the game is that it feels intuitive to use and thus ‘native’ to its distribution channel. Various gesture controls have been integrated into gameplay such as swiping over fields to plant crops, tapping on production units to collect products, dragging resources on buildings to start production, etc. Furthermore, ‘Hay Day’ is very successful in providing gradual on boarding to players. Initially, a short tutorial that is integrated into the gameplay is provided (a scare crow character guides the player’s actions) and a limited amount of features is available. As the game progresses and the skill of the player builds up, complexity layers are added in the form of new features (e.g. new production units).

Game *Controllers* allow players to perform actions within a game (Bjork & Holopainen, 2004) and are here designed to foster fluid interaction, since they are native to the device. The interface features both the archetypal type of controller, which is the button, as well as areas where the construction of game elements is possible (e.g. field to swipe over and plant crops). ‘Hay Day’ facilitates a *Smooth Learning Curve*, by providing players with the possibility of smoothly progressing from novice to master and by adjusting the difficulty of challenges to player skills (Bjork & Holopainen, 2004). This ensures a *Right Level of Difficulty* which is relevant to the skill of the player, initially allowing a *Limited Set of Actions* and gradually introducing *New Abilities* via complexity layers such as new farming methods, resources, production units etc.

Player-centred Strategy

In ‘Hay Day’ every player can decide on a personal strategy of how to play the game, since the gameplay has been designed to allow for freedom in managing a farm in various ways. The player is given a farm to run and he/she is solely responsible for its development. Although there are achievements to be completed which will provide rewards, they are not obligatory to progress in the game. ‘Hay Day’ therefore allows for different play objectives and styles (e.g. players may choose to focus on acquiring a large number of fields, on building a well structured and nicely decorated farm, etc.). This freedom is extended to smaller in-game choices as well, such as deciding the price of goods sold in the farm’s shop to make them competitive to other farmers.

‘Hay Day’ features the *Freedom of Choice* game design pattern since players have the ability to make choices in the game and these choices have different effects in the progress and outcome of the game (Bjork & Holopainen, 2004). This freedom is coupled with *Tradeoffs*, and together allow players to define their own goals in the game facilitating a *Perceived Chance to Succeed*, according to which players feel that they can influence the game and choose what sort of outcomes it will have (Bjork & Holopainen, 2004). In addition, making choices that influence the game’s progress and outcomes can account for *Creative Control* as well as *Experimenting*, which both allow players to express themselves in the game. Creativity is facilitated by having control over the design of the farm, as well as the way it develops over time. *Score* is also featured in the game, since points are awarded for good performance.



Figure 5-8: Heavily decorated VS simple and functional farm (Supercell, 2012)

Player Keeps Coming Back

‘Hay Day’ features mechanics aimed at facilitating replayability, inviting players to keep coming back to the game. There are some design elements that enhance this, such as notifications sent to the user’s device in the form of updates on farm activities. Coupled with various production times for different goods, these can successfully enhance the core game loop, thus motivating the player to often return to the game to check production progress. Revisiting is also reinforced via the feature adding element, where in-game activity results to gaining experience, then levelling up and then unlocking additional game features (e.g. new production units). This loop motivates the user to stay in the game for longer in order to gain experience and see what comes next.

‘Hay Day’ features the *Replayability* game design pattern, which can be found in games designed to be played many times and refers to the level to which a game provides new challenges or experiences (Bjork & Holopainen, 2004). To allow players keep coming back to the game easily and quickly, *Interruptible Actions* and *Save-Load Cycles* are supported. These two design patterns are particularly important in a mobile context and refer to actions that can be interrupted without affecting the game as well as saving and loading game states successfully (Bjork & Holopainen, 2004).

Memorable Visual Style

‘Hay Day’ has a memorable look, which conveys the attributes of the gameplay model. Graphics are eye pleasing and complement the overall happy and relaxing creative vision of the game. The environment and characters are cartoon-like, while the game features colourful, stylised, clean graphics complemented by animation with a touch of humour (e.g. chickens ‘drop dead’ when hungry, to get bacon from pigs they go in the sauna, etc.). Finally, the game is two-dimensional.

‘Hay Day’ features a 2D *Game World*, where movement is limited to a two-dimensional plane. Via its visual design the game facilitates *Consistent Reality Logic*, since all graphical elements are aesthetically coherent and stylistically consistent. *Consistent Reality Logic* is also extended to game metaphors, which represent natural ways of being in the real world (Bjork & Holopainen, 2004). The representations of most farming activities although simplistic, convincingly mimic real world activities (e.g. drag the sickle over the crops to harvest).



Figure 5-9: 2D ‘happy’ country side visual style (Supercell, 2012)

The following table summarises the most prominent characteristics of ‘Hay Day’ as discussed in the above game review:

Game is device specific and mechanics take advantage of touch-based controls
Different play styles and objectives are facilitated
Player-driven strategy is allowed
The system enhances retention and drives users keep coming back
The game makes use of gradual feature adding
Animation enhances the game's style and adds a touch of humour

Table 5-3: 'Hay Day' most prominent mobile game design characteristics

5.2.4 Bejeweled

'Bejeweled' (PopCap, 2007) is a mobile classic. Since the original release, various other versions of the game have emerged (e.g. Bejeweled 2, Blitz) that are all part of the 'Bejeweled' franchise and retain the same core mechanic. It is a game very simple in concept. The screen is filled with randomly positioned rows of gems of different shapes and colours and the user is called to swap any gem with an adjacent one to create matches of three. Creating the match will award points and make the matching gems disappear so as for new random ones to fall in the board and take their place. The mobile game features various modes to allow variation but the core match three mechanic is retained across all modes. For example, there is the 'classic' mode where players match and collect points to advance from level to level, the 'zen' mode where players can endlessly match without worrying about goals or time, and the 'diamond mine' mode where matching allows to dig the ground and reveal treasures and bonuses.

Immersive Gameplay

Matching patterns can be a cognitively appealing activity and in 'Bejeweled' it is cleverly utilised as the core gameplay mechanic. Pattern matching is often encountered in different kinds of games, which invite players to recognise and create patterns. 'Bejeweled' utilises pattern matching as the core game mechanic in order to facilitate habit forming, an addictive element of gameplay. Players thus take pleasure

of creating order out of chaos, via organising the gems through competitive matching. Furthermore, 'Bejeweled' features a colourful and vibrant two-dimensional game world, which although constructed in a grid format, it remains effective and aesthetically consistent to the theme of the game (e.g. shaded buttons, decorated UI outlines, reflections etc.).

Via pattern matching 'Bejeweled' facilitates *Immersion*, which can make the experience of playing the game very satisfying. Bjork and Holopainen write: 'Many simple puzzle-based games such as Bejeweled can capture players' attention through their cognitive demands so that the player becomes unaware of how much time is spent playing them' (2004). Although players are deeply focused on in-game interactions however, this pattern does not imply that they are unaware of their surroundings. 'Bejeweled' also features a 2D *Game World* where movement is limited to a two-dimensional plane. *Consistent Reality Logic* is achieved in the game via visual design, since all graphical elements are aesthetically coherent and stylistically appear to be parts of the same world.



Figure 5-10: Match-3 mechanic (PopCap, 2007)

Simple and Intuitive

‘Bejeweled’ is a simple game that anyone can pick up and play, without the need for a tutorial. Even the first time player can master the core mechanic in a few minutes. This can make the game appealing to a wide audience range. The game’s simplicity is also facilitated by the fact that a clear problem is presented to the player (randomly placed gems) and a simple solution is required (organise them via matching). This simplicity coupled with intuitive touch controls and short play sessions make the game appealing, utilising the key affordances of the device. Additionally, simplicity reduces the consequence of failure in the game.

The game features *Puzzle Solving* in the form of action that can be solved through reasoning (create matches of three similar gems). However, it remains accessible to a wide range of players, since the *Right Level of Difficulty* is achieved and the main goal of the game becomes clear within a short time of experiencing the system. Facilitating *Strategic Knowledge*, which relates to information about in-game actions and events the understanding of which makes the game easier for players, further assists the *Right Level of Difficulty*. The simplicity of the game is also evident in the *Game Controllers*, which are designed to foster fluid interaction based on dragging the gems horizontally or vertically on the grid.

Positive Feedback

Another positive characteristic of ‘Bejeweled’ is that it provides immediate and positive feedback for user actions. When the user does well in the game the score increases, but there are various visually engaging effects that take place as well. Additionally, verbal feedback is also utilised. After a string of successful matches a voice announces: ‘Excellent’ or ‘Awesome’ (while the word is also written across the board). Research by Fogg and Nass (1997) has found that systems that flatter are rated more favourably among users. Therefore, this feeling of accomplishment evoked by visual and verbal rewards, can account for increased engagement.

Rewards refer to what players perceive as positive for completing the goals of the game and in ‘Bejeweled’ take the form of scoring, combos and achievements. However, as mentioned above the game is very good at also providing *Illusionary Rewards*, which although do not quantifiably help in completing a goal, are still perceived positively by players (e.g. flattering mechanic). *Score* is also featured in the game, since points are awarded for good performance.



Figure 5-11: Positive feedback provided via visuals and sound (PopCap, 2007)

Interruptibility

‘Bejeweled’ features mechanics aimed at facilitating interruptibility. It is easy for the player to get out of the game at anytime and easily come back, since the current state of the game is retained. Progress and score are saved thus making it easy for the player to pick up the game and play even for a very short period of time. This is key for the mobile context and particularly useful when the device used is a mobile phone.

‘Bejeweled’ allows players to keep coming back to the game easily and quickly by supporting *Interruptible Actions* and *Save-Load Cycles*. These two design patterns are particularly important in a mobile context and refer to actions that can be interrupted without affecting the game as well as saving and loading game states successfully (Bjork & Holopainen, 2004).

The following table summarises the most prominent characteristics of ‘Bejeweled’ as discussed above:

Cognitively appealing functions like sorting/matching are embedded in gameplay
Gameplay facilitates short play sessions, which fits the device’s context of use
Gameplay presents a clear problem and a simple solution
Gameplay is supported by immediate feedback
The system is flattering

Table 5-4: ‘Bejeweled’ most prominent mobile game design characteristics

5.2.5 Bookworm

‘Bookworm’ (PopCap, 2009) is a puzzle word game, originally developed by PopCap for the PC and later redesigned and ported for mobile devices. The concept is simple, since from a playing board featuring rows of random letter tiles the player must synthesise words to make them disappear from the board. Then new tiles will fall from the top of the screen to take the place of the disappearing ones. Letter tiles can be linked together either horizontally, vertically or in a diagonal to form words, the only requirement is however that the tiles are adjacent to each other. The more tiles used to form a word the more points will be awarded. There are various other elements that complement the core mechanic, such as ‘burning tiles’ that need to be used in a word before reaching the end of the board. Additionally there are ‘reward tiles’ which award more points when used as well as ‘bonus’ words, which again add to the score when formed. The game features a main character named Lex, a green

worm, eating the tiles utilised in a word to make space for the new ones. If the game comes to a point where no new words can be detected the player can shake his phone to shuffle the tiles.

Polished Gaming Experience

‘Bookworm’ features various reward systems including achievement boards and word lists, which allow users to track their progress. Additionally, there is a word history feature, which helps players see how many words of a certain letter length were correctly formed in a play session. Word groups are predetermined and unlock when the player forms the first word of the group. Then the player can aim for more of the same group to complete the set (e.g. form the word ‘dog’ to unlock ‘pets’ family). Such mechanics are well suited to the context as well as the game theme and may become motivating for players. Suited to the context is also the fact that the classic game mode features no timer, which is logical for a word game where the player must often take some time to think and find the best possible word. Here, speed is not the key therefore the pace of the game is slower than others but again remains true to the context. Finally, ‘Bookworm’ facilitates on-boarding, since challenges remain relevant to player skill and levels of difficulty are gradually added as the levels progress.

A key game design pattern featured in ‘Bookworm’ is *Puzzle Solving*, which refers to actions that can be solved through deductive or inductive reasoning (Bjork & Holopainen, 2004). *Strategic Knowledge* is also present via the above-discussed mechanics that help communicate information about game actions, rules, events and evaluation functions. Clear *Strategic Knowledge* assists *Stimulated Planning* here, which allows players to plan what to do next in the game and informs play strategy. Furthermore, the reward systems and word lists provide *Extra-Game Information*, which can help track performance. Finally, ‘Bookworm’ features a *Smooth Learning Curve* where the *Right Level of Difficulty* as well as the *Right Level of Complexity* is achieved in the game.



Figure 5-12: The word history user interface (PopCap, 2009)

Game is Device Specific

The way the game has been ported for mobile devices, takes advantage of the opportunities of the distribution channel. The interface features intuitive gesture controls, while small details such as the ‘shake phone to shuffle tiles’ mechanic add to the intuitive flow of the gameplay. Furthermore, an efficient auto save functionality has been build into the game, which saves everything in the current session when gameplay is interrupted for any reason (even the currently selected tile sequence). This type of functionality makes the game truly device specific since it allows for short play sessions and fosters interruptibility.

‘Bookworm’ supports interruptibility, which is key for mobile games and thus features *Interruptible Actions*, allowing players to keep coming back to the game easily and quickly. Interruptibility is supported by the *Save-Load Cycles* game design pattern, which is about saving and loading game states successfully when the game is interrupted.

Immersive Gameplay

Due to limitations in game complexity caused by device restrictions, many mobile game designers often come up with highly engaging but simple mechanics, which can however account for increased engagement. As discussed previously in this section ‘Bejeweled’ featured the simple pattern-matching mechanic and ‘Bookworm’ features a sorting mechanic. The game cleverly utilises the idea of sorting to challenge the human brain and increase immersion via cognitive satisfaction. This cognitive stimulation is achieved via fun word-puzzling interactions. The polished gameplay experience also extends to world design, which provides a robust library look and feel.

Bjork and Holopainen (2004), refer to this game design pattern as *Immersion* in the activity of play. More specifically they characterise it as *Cognitive Immersion* which: ‘is based upon the focus of abstract reasoning and is usually achieved via complex problem solving’ (Bjork & Holopainen, 2004). ‘Bookworm’ also features a two dimensional *Game World* where movement is limited to a 2D letter grid and which remains aesthetically consistent to the theme of the game.



Figure 5-13: A general view of the game’s interface (PopCap, 2009)

The following table summarises the most prominent characteristics of ‘Bookworm’ as discussed in the above game review:

Game stays true to context and provides a polished experience
Gameplay facilitates analytic thinking and strategic planning
Skills development tracking is allowed via game ‘history’
Interface is intuitive and features gesture controls
Autosave functionality saves all data in the current session and allows interruption
Natural skill is incorporated into the core mechanic

Table 5-5: ‘Bookworm’ most prominent mobile game design characteristics

5.2.6 Tetris

‘Tetris’ is a classic puzzle game available on mobile devices by Electronic Arts (2008). The original game dates back to 1989 and Nintendo’s Game Boys, with various sequels being released from then onwards marking the start of a whole new genre of similar puzzle games. The game is all about creating lines of blocks in optimum ways. The player has seven types of blocks available to create solid structures. These blocks, called ‘Tetrominoes’ drop gradually from the top of the screen and keep moving downwards till they reach the bottom. The player must slide and rotate the blocks as they fall to achieve an optimum position so as to form structures without holes. Once an entire row is created the blocks making it up disappear to leave room for new ones and points are awarded. The game ends when the stack of blocks reaches the top of the screen and there is no more space for ‘Tetrominoes’ to fall. ‘Tetris’ features a simplistic interface, with dropping blocks of vibrant colours, without much detail. This type of design can appeal to various age groups as it does not feature any age specific characteristics and is gender neutral.

Intuitive Controls

The mobile version of the game is well redesigned and controls have successfully been transferred to the device specifications in a highly intuitive manner. The game features fluid touch screen controls as well as a ‘one-touch’ mode. In this mode possible positions in the form of ghost blocks appear on the structure while blocks are falling and the user can tap to get alternatives. Once he/she finds the optimal alternative, he/she can tap again to position the block. This mode is mobile friendly as it allows one finger gameplay.

The *Controllers* of the game foster fluid interaction and are based on gesture controls. According to the game play mode selected, ‘Tetrominoes’ can become the controllers in the form of tappable buttons (tap to position).

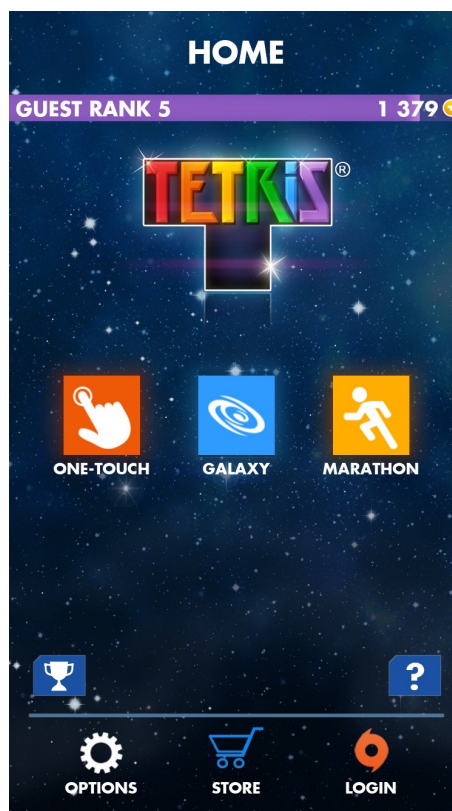


Figure 5-14: One-touch is the first of the available modes of the game (Electronic Arts, 2008)

Player-centred Strategy

Tetris is essentially a building game where to score points the player must create as many lines as possible via forming solid block structures without holes. Although this is the main objective, the gameplay allows player freedom to choose the best strategy to help achieve this. For instance, forming big structures is a more risky approach as one should wait for the right block that will allow multiple lines formation at once. On the other hand, it may bring more rewards. On the contrary, a less risky approach would involve the player focusing on creating smaller structures and forming lines as soon as the right block becomes available, therefore keeping the structure close to the bottom of the screen. The game therefore fosters player-centred strategy since it allows multiple paths to succeed.

Via allowing for player-centred strategy, the feeling of control over the events and outcomes of the game is increased and *Empowerment* is facilitated. This is coupled with *Tradeoffs*, which add value to the strategy chosen by players during gameplay. *Experimentation* is also facilitated, since multiple paths to succeed are allowed in the game, as well as *Freedom of Choice* over choosing a play strategy. The combination of the above allows for a *Perceived Chance to Succeed*, which increases the feeling of controls in the game.

Order out of Chaos

‘Tetris’ can be an addictive game. One of the key reasons for user engagement is the ‘create order out of chaos’ mechanic that has been cleverly utilised as the core mechanic of the game. In ‘Tetris’, unfinished tasks in the form of falling blocks that need to be put into place are constantly thrown to the player. Additionally, since the given problem is simple and the player already knows the solution the game becomes more compelling. As soon as the player positions a block and the feeling of order is evoked, the next one comes along. This loop is fostered by simple yet functional game mechanics, therefore keeping the player immersed in the game. On the same

time challenge is regulated, since the speed of the falling blocks starts off slow and starts gradually speeding up to increase difficulty.

Immersion is a highly engaging function of games and can make the experience of playing the game very satisfying (Bjork & Holopainen, 2004). ‘Tetris’ as a puzzle-based game, captures players’ attention through its cognitive demands. It therefore features *Puzzle Solving* in the form of actions that can be solved through reasoning (position falling blocks to form rows), coupled with *Cognitive Immersion*, which is based on this reasoning, evoked via complex problem solving. ‘Tetris’ also facilitates a *Right Level of Difficulty*, since the speed of the game increases as the game progresses and the performance of the player gradually becomes better.

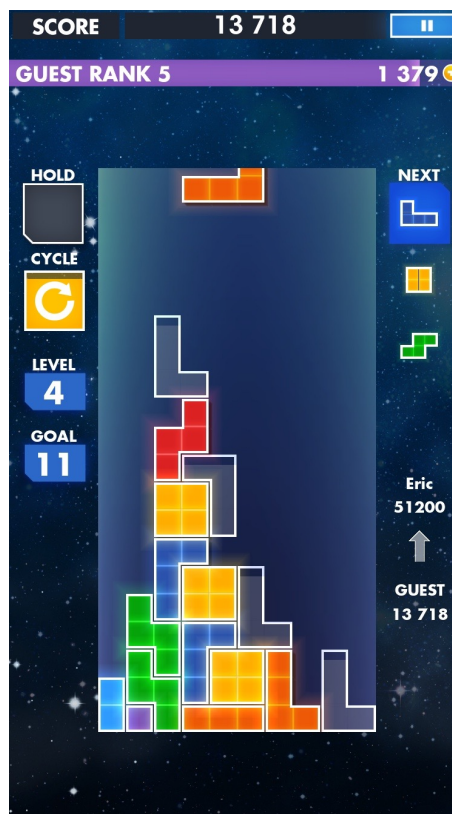


Figure 5-15: A general view of the game’s interface (Electronic Arts, 2008)

The following table summarises the most prominent characteristics of ‘Tetris’ as discussed in the above game review:

The user interface is simple and intuitive
Gameplay features fluid touch-screen controls
Gameplay presents a clear problem and a simple solution
The game allows multiple paths to succeed.
Natural skills are incorporated into the core mechanic
The visual style of the game is simple, sharp and inviting through its minimalism

Table 5-6: ‘Tetris’ most prominent mobile game design characteristics

5.2.7 Diner Dash

‘Diner Dash’ is a mobile strategy game by PlayFirst (2012). The game was originally developed for the PC, however it has since been published on multiple devices. As one of the most popular downloadable games of all times it has inspired a ‘Diner Dash’ franchise featuring multiple sequels including ‘Diner Dash: Flo on the Go’, ‘Diner Dash: Hometown Hero’ and the recent ‘Diner Dash Rush’ among others. In the game the player controls Flo who decides to open and run her own restaurant. Flo’s multiple roles mean that she needs to play hostess, waitress and cashier all at the same time. The main aim of the game is to keep customers happy providing them with a fast and satisfying service. Whenever a new level begins and the diner opens for business, customers soon come in and it is Flo’s job to keep them happy by completing a set of steps including sitting them, taking their order, serving their food, collecting the bill and clearing the table. A set of heart icons over the customers’ heads indicate their level of happiness and if something goes wrong (e.g. they wait too long to be seated) all the hearts will gradually disappear and they will leave the restaurant angry. By keeping customers happy and ensuring a flowing service, the player will score points to make it to the next level. Completing the same action in a row and matching customers’ clothing colour to seat colour will also earn extra cash. As levels progress the customer base becomes more complex and additional responsibilities are added to increase gameplay complexity.

Context Specificity

In ‘Diner Dash’ interacting with the game system is very simple and mainly involves point and click. This makes the game a great fit for the mobile touchscreen, where clicks are translated to taps. Additional in-game controls like dragging customers to their seats with one finger and tapping to queue game actions feel intuitive. The simplicity of controls makes the game easy to learn and play and therefore suitable for a wider audience, looking for a fun and easy mobile gaming experience. Furthermore, the game features short play sessions in the form of short mini-levels, which are perfect for mobile as there is not a lot of time commitment involved.

In ‘Diner Dash’ *Controllers* operate via gesture controls and foster intuitive, device specific interactions such as tapping and dragging. The interface features primarily the archetypal type of controller, which is the button or in this case the hotspot, which the player has to tap on to perform an action (e.g. tap on table to seat guests, tap on counter to pick up order etc.). Another game design pattern featured in ‘Diner Dash’ is *Levels*, which refer to parts of a game in which all player actions take place until a certain goal has been reached (Bjork & Holopainen, 2004). Level design is however here based on mini-levels architecture, where the primary activities of the player remain the same but the puzzles change (e.g. speed of service) to facilitate different levels of difficulty.

Gameplay Variety

‘Diner Dash’ features a playful, cartoon-like world, which is simple yet suitable to highlight the main game model. It almost feels like an old-school arcade game, and this is much of where its visual appeal comes from. As with other mobile games discussed previously in this review, the game adopts a simpler approach to visual design in comparison to traditional computer games, which is both appealing to a wider audience and suitable for the device restrictions. Additionally, since the gameplay remains the same as the levels progress, variation is added via different

restaurant and client types. New types of clients however tend to introduce new challenges since they tend to be more demanding.

In 'Diner Dash', *Varied Gameplay* is achieved via changing the scenery according to the theme (e.g. different types of restaurants) as well as the client types gradually introduced. This type of *Varied Gameplay* although it does not change the core mechanic of the game, it adds visual interest and affects the configuration of the game, since different types of characters have different characteristics that introduce new challenges (e.g. impatient clients). Furthermore, 'Diner Dash' features a *Smooth Learning Curve* since originally a *Limited Set of Actions* is introduced (e.g. collect orders and serve), while new actions to be performed are gradually presented to players (e.g. seat clients, collect orders, serve, clean table). On the same time, *New Abilities* are gradually introduced to help the player cope with the demands of new types of clients.



Figure 5-16: Various types of clients introduce new challenges (Play First Inc, 2010)

Come Back and Replay

Another feature of the game, which may encourage players to come back and replay a level, is the three stars system. 'Diner Dash' features multiple levels and upon

completion of each level the player can be awarded up to three stars according to performance. The first two have to do with reaching a certain score while the last one is awarded when the player successfully accomplishes a certain goal for the given level. This type of star system ensures that a game that is easy to learn and play remains hard to master, thus retaining a needed level of complexity for those up to the challenge. In most cases the third star is not easy to get but because levels are quite short to complete, users can easily return and try again at any point.

The *Replayability* game design pattern can be found in games designed to be played many times and refers to the level to which a game provides new challenges or experiences when played again (Bjork & Holopainen, 2004). In ‘Diner Dash’, *Replayability* is achieved by letting the players compare results between games via the three stars system. This stars system can help players measure their level of game mastery and relates to *Score*, which is here the visual representation of the player’s success in the game.

Interruptibility

‘Diner Dash’ features mechanics aimed at facilitating interruptibility and allows players to get out of the game at anytime and easily come back without losing progress. The current state of the gameplay session as well as the score are saved, thus making it easy for players to pick up the game and play even for a very short period of time. This is particularly useful when the device used for gaming is a mobile phone.

‘Diner Dash’ supports interruptibility via *Interruptible Actions* and *Save-Load Cycles*. *Interruptible Actions* refer to actions that can be interrupted without affecting the game while *Save-Load Cycles* refer to saving and loading game states successfully (Bjork & Holopainen, 2004). Both game design patterns are key for the mobile context.

The following table summarises the most prominent characteristics of ‘Diner Dash’ as discussed in the above game review:

The user interface is simple and intuitive
Gameplay features fluid touch-screen controls
The game allows for short play sessions
Goals become understandable in a brief period of experiencing the system
Multiple play-throughs are encouraged and level replay facilitated via star system
The visual design conveys the attributes of the game model in a memorable way
The game facilitates interruptibility

Table 5-7: ‘Diner Dash’ most prominent mobile game design characteristics

5.2.8 Cut the Rope

Along with ‘Angry Birds’ discussed previously, ‘Cut the Rope’ by ZeptoLab (2010) is one of the massively popular mobile puzzle games on the iPhone. The main aim of the game is to feed candy to a green monster named Om Nom. The game begins with a very short video introduction, where there is a knock on the door and a box labelled ‘Feed with Candy’ is delivered. Next the player is inside the box where the gameplay takes place. ‘Cut the Rope’ is essentially a physics game, therefore the simple task of feeding Om Nom candy is complicated by the fact that the candy dangles on ropes, out of the monster’s reach. The player needs to thus slide one or two fingers across the screen to cut the ropes in such a way that the candy lands in Om Nom’s mouth, preventing it from falling off the screen. Furthermore, different levels feature different types of traps and cutting the wrong rope may result in the candy crashing on top of the trap. Apart from traps there are also other elements that help direct the candy towards the platform where Om Nom stands on. These elements may include sliding rails and flying bubbles, among others, and assist the player move the candy away from traps and obstacles. Gameplay is organised in ‘boxes’, which act as game worlds, each featuring a set of levels with specific characteristics. Different elements are added in every new ‘box’, while the game becomes progressively more difficult as the player gets to the last levels in any given ‘box’.

Device Specificity

One of the main strengths of ‘Cut the Rope’ is its clean interface featuring responsive touch controls, which feel intuitive on the mobile device. Finger swipes for cutting ropes are the main interaction control used in gameplay, however secondary elements also feature simple controls such as bubbles that need to be tapped to exhaust air and move the candy. In addition, the way levels have been constructed allows for short play sessions, which is another element that fits the mobile game design philosophy well.

‘Cut the Rope’ features *Controllers* that foster intuitive, device specific interactions based on gestures such as swiping and tapping. *Levels* are also featured in the game and are organised in mini-levels, which allow for shorter play sessions. As previously mentioned, the mini-levels architecture is based around the idea of ‘boxes’, each featuring a set of levels with specific characteristics. For each ‘box’ the primary activities of the player remain the same but the puzzles change to facilitate different levels of difficulty.

Visual Style

The visual style in ‘Cut the Rope’ is clean and vibrant. Graphics are sharp, colourful and bright with a cartoonish quality. However this cartoonish quality of the graphics does not make the game feel simplistic or overly cute; graphics are solid and have a recognisable look. Additionally, animation is fluid and relatable (e.g. the Om Nom occasionally moves around on its platform and points at its open mouth, reminding the player it is waiting for candy). ‘Cut the Rope’ is a two-dimensional game.

The *Game World*, which is featured in ‘Cut the Rope’, is 2D and thus movement is limited to a two-dimensional plane. In addition the game is first person and two-dimensionality expands to graphical representations. The game features *Consistent Reality Logic* in its visual design, since all graphical elements are aesthetically coherent and stylistically consistent. Finally, *Consistent Reality Logic* is expanded to

game metaphors representing the real world, especially when mimicking physical laws in the movement and behaviour of the ropes and the dropping candy.

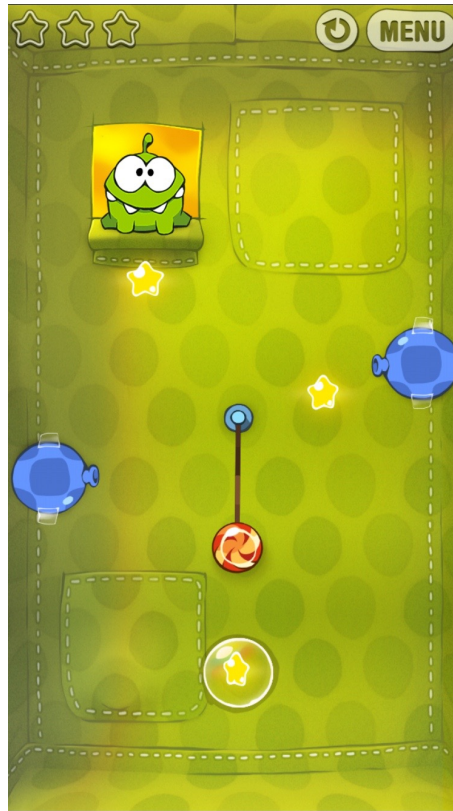


Figure 5-17: The visual style of the game (ZeptoLab, 2010)

Replay Value

The replay value in 'Cut the Rope' is high and facilitated via the three stars system. The game allows players to replay each level, aiming at collecting performance stars, which can be appealing to those looking for some extra challenge. However, collecting the stars is not mandatory to progress in the game, which also makes it accessible by players looking for a quicker pace gaming experience. Although various other games feature the star system mechanic, in 'Cut the Rope' the innovation comes from the fact that the three stars are actually visible on the level screen. Therefore the player needs to find a way to collect them, while cutting the ropes to feed the candy to Om Nom. This increases the challenge in the level, as a

particular strategy should be identified in order to both collect stars and successfully feed the monster. This simple mechanic is thus cleverly utilised in the game to increase replayability and motivate players to keep coming back for another play through.

‘Cut the Rope’ features the *Replayability* pattern, which is found in games designed to be played more than once (Bjork & Holopainen, 2004). Here, *Replayability* is achieved by allowing puzzles to be solved in several ways via player-centred strategy (discussed below) as well as by letting the players compare results between games via the three stars system. This star system can help them measure their level of *Game Mastery* and relates to *Score*, which is here the visual representation of the player’s success in the game. Finally, ‘Cut the Rope’ features *Interruptible Actions* and *Save-Load Cycles*, to allow players to easily and quickly come back to a play session after being interrupted. Supporting interruptibility is key for the mobile context and can assist *Replayability*.

Player-centred Strategy

Although the game appears to be simple in concept, it often requires a considerable amount of strategy to complete levels with three stars. Players need to think about the timing and order of cutting the ropes to make sure the candy falls into Om Nom’s mouth and collects all the stars while falling. Additionally, there are other level elements that need to also be strategically considered and overall gameplay requires dexterity, well planned moves and good spatial awareness. For every level and with the introduction of new elements, the strategy of the player may change in order to achieve the best result. According to how the player approaches the game experience strategy can also be altered. For a fast play through the player needs to achieve a quick path between candy and Om Nom, while to reach three stars all possible routes should be considered. Obviously this is often a matter of trial and error and the player may have to replay the level a couple of times before achieving the best score. ‘Cut the Rope’ is also successful in facilitating on boarding since the difficulty of the puzzles gradually increases, as levels progress and the skill of the player builds up.

Through trial and error *Experimenting* is facilitated in the game, since multiple paths to succeed are allowed. This is coupled with *Tradeoffs*, according to which the player has to choose between options during gameplay, comparing values against each other (Bjork & Holopainen, 2004). There is also *Freedom of Choice* over choosing a play strategy (quick path between candy and Om Nom to complete the level or reaching all three stars to achieve maximum score). Via allowing player-centred strategy *Empowerment* over game events is facilitated and *Stimulated Planning* is encouraged, which allows players to plan what to do next in the game. Additionally ‘Cut the Rope’ features the *Right Level of Complexity* for each level, starting off with a *Limited Set of Actions* and gradually introducing *New Abilities* as the challenges become more difficult.

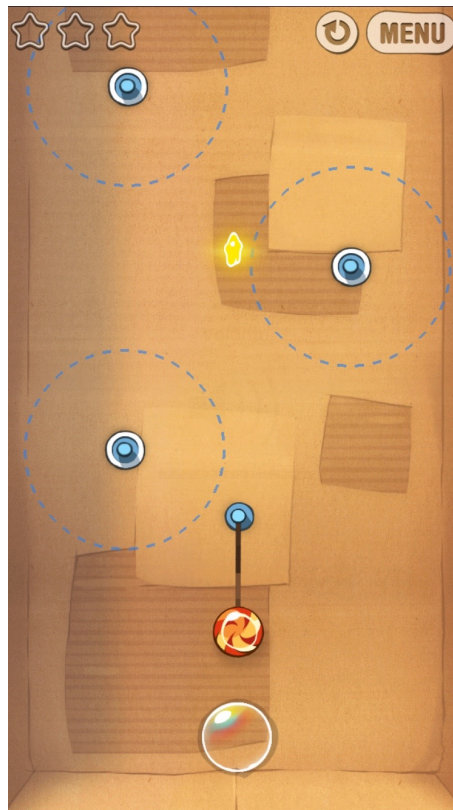


Figure 5-18: An example of a puzzle in the game (ZeptoLab, 2010)

The following table summarises the most prominent characteristics of ‘Cut the Rope’ as discussed in the above game review:

The user interface is simple and intuitive
Gameplay features fluid/responsive touch-screen controls
The game allows for short play sessions
Star system is incorporated in the gameplay
The visual design conveys the attributes of the game model in a memorable way
Complexity layers are added as the user’s understanding of the system expands
Gameplay facilitates error correction via trial-and-error

Table 5-8: ‘Cut the Rope’ most prominent mobile game design characteristics

5.2.9 Design Elements Extracted from Mobile Games

The first step of the review was to consider the eight (8) case studies as described above to identify design elements not otherwise covered by the design guidelines, which were considered appealing and could contribute to engagement. Following, case studies were considered again in relation to the structural framework of Game Design Patterns developed by Bjork and Holopainen (2004) to identify patterns shared amongst the games. These two pieces of work will inform the final design guidelines for mobile game-based learning, synthesised and discussed on the next and final section of this chapter. In the following short paragraphs a number of design elements and patterns, which could be used to support interface design and game design and to enhance engagement, have been drawn together and are overviewed.

Interface Design: In all reviewed games the interface was simple and intuitive and in the majority of the cases a tutorial was not necessary to allow the player to start interacting with the system. At the same time, games were designed for the mobile context and were device-specific with regards to interface design, while game mechanics utilised the touch-based controls. In the majority of the games, gameplay

presented a clear problem and a simple solution, while goals became clear in a brief period of experiencing the system. In all cases gameplay was supported by immediate feedback. Finally flexibility was facilitated via allowing interruptibility of gameplay.

Game Design: With regards to game design, there were shared characteristics between case studies including the use of cognitively appealing functions, such as sorting and matching, embedded in gameplay. Additionally all games allowed for both short and long play sessions. Gameplay strategy was in many cases facilitated via trial-and-error mechanics, while gradual feature adding was utilised in the majority of the case studies. Importantly all games maximised reward and minimised punishment. The visual design conveyed the attitudes of the game model and was simple, sharp and inviting. Cartoonish characters with a bit of humour were utilised in many of the games. Finally, not all games featured a backstory but where they did, the story was often divided in sections and gradually presented in-between levels.

Engagement: A number of important guidelines with regards to engagement were also extracted via the case studies analysis. Engaging gameplay was achieved via balanced pace and challenge. Gameplay appeared to be neither too fast nor too slow, while complexity layers were added as the player's understanding of the system expanded. Gameplay challenge and tempo was therefore either in sync or adaptable to the player's skill. Additionally, in most of the games different play styles and objectives were facilitated. Furthermore, all games fostered success and were rewarding rather than punishing. Finally, engagement was increased via cognitive satisfaction or mental stimulation.

The following table presents the design elements extracted and collected from the case studies review. These are therefore components of appealing design, shared among all or a number of the games and which could arguably have a positive impact on engagement.

	Angry Birds	Plants VS Zombies	Hay Day	Bejeweled	Bookworm	Tetris	Dinner Dash	Cut the Rope
User interface simple and intuitive.	✓	✓	✓	✓	✓	✓	✓	✓
Gameplay organised in short play sessions (use of mini-levels).	✓	✓		✓		✓	✓	✓
Goals clear in a brief period of interacting with the system.	✓	✓	✓	✓	✓	✓	✓	✓
Complexity layers added as the user's understanding of the system expands.	✓	✓	✓	✓	✓	✓	✓	✓
Reward maximised and punishment minimised.	✓		✓	✓		✓		✓
Game guides players on improving performance.	✓				✓			✓
Player-driven strategy supported.	✓	✓	✓	✓		✓	✓	✓
Multiple play-throughs encouraged.	✓		✓				✓	✓
Clean, sharp, cartoonish visual design.	✓	✓	✓		✓		✓	✓
Use of backstory.	✓	✓						
Use of humour in visuals and/or story.	✓	✓	✓					✓

Table 5-9: Elements of appealing design, extracted from the case studies

Finally, the following table presents the game design patterns collected from the second step of the case studies review. These are therefore components of effective game design, shared among all or a number of the games examined and which could arguably have a positive impact on gameplay.

	Angry Birds	Plants VS Zombies	Hay Day	Bejeweled	Bookworm	Tetris	Dinner Dash	Cut the Rope
Smooth Learning Curve	✓	✓	✓		✓		✓	
Right Level of Difficulty	✓	✓	✓	✓	✓	✓		
Perceived Chance to Succeed	✓		✓			✓		
Right Level of Complexity	✓	✓			✓			✓
Limited Set of Actions	✓	✓	✓				✓	✓
New Abilities	✓		✓				✓	✓
Rewards	✓			✓				
Illusionary Rewards	✓			✓				
Experimenting	✓	✓	✓			✓		✓
Empowerment	✓	✓				✓		✓

Game Mastery	✓	✓						✓
Tradeoffs	✓	✓	✓					✓
Memorising	✓	✓						
Varied Gameplay		✓					✓	
Freedom of Choice		✓	✓			✓		✓
Levels							✓	✓
Narrative Structures		✓						
Cut-scenes		✓						
Controllers			✓	✓		✓	✓	✓
Creative Control			✓					
Game World	✓		✓	✓	✓			✓
Consistent Reality Logic	✓		✓	✓				✓
Replayability			✓				✓	✓
Interruptible Actions			✓	✓	✓		✓	✓
Save-Load Cycles			✓	✓	✓		✓	✓
Immersion				✓	✓	✓		
Puzzle Solving				✓	✓	✓		
Strategic Knowledge		✓		✓	✓			
Stimulated Planning					✓			✓
Extra Game Information					✓			
Score	✓		✓	✓			✓	✓

Table 5-10: Game design patterns (Bjork & Holopainen, 2004) featured in the case studies

Both the design elements and the game design patterns extracted and collected from the case studies review will be used to extend the design guidelines developed on the previous section. Drawing on both pieces of research thus far presented in this chapter, the examination of existing theory as well as the case studies review, the following section will present the final set of design guidelines for mobile game-based learning.

5.3 Guidelines for Designing Mobile Learning Games

In this section the final design guidelines for mobile game-based learning are being proposed, in the form of four sets as presented below. These design guidelines have been drawn together from the guidelines synthesised through the review of existing literature as described on the first section of this chapter, as well as the design criteria gathered via the case studies analysis presented above. The first two sets relate to learning design and engagement and the subsequent two to usability and game design. The final guidelines that have been advanced can be used to inform the design of mobile game-based learning applications and constitute the second contribution of this research, as described in Chapter 3 (Research Design). These guidelines have also been used to inform the design of the mobile game prototype which was developed as the next stage of this research.

The first set of guidelines presented on Table 5-11, is made up of six criteria which can be used to assess the learning design of a mobile game application. These criteria include: the ability of the game to promote self-direction, support independent learning, provide a personalised experience, support active learning, feature replayable micro content and be appropriate to context. Here the final criterion as presented on the first sub-section of the first section above (5.1.1 Design Guidelines for Learning), was the ‘ability of the game to be engaging’ and has been merged to subsequent guidelines that focus on the design of engaging mobile game-based learning.

L1	Promote self-direction
	<ul style="list-style-type: none">- Choice over the learning task- Allow customisation of content according to personal needs- System should provide constant support- Control over the pace of learning
L2	Support independent learning
	<ul style="list-style-type: none">- Control over where and when learning takes place- Flexible and accessible content, across contexts- Design for learner’s personal device- Learning independent from others

L3	Provide a personalised experience
	<ul style="list-style-type: none"> - Support a range of expertise - Challenge adjustable to learner's competence - System adaptability to the learner's progressively evolving skills - Ability to monitor progress
L4	Support active learning
	<ul style="list-style-type: none"> - Encourage problem solving - Promote task-based learning - Opportunities to test ideas and get feedback - Game goals aligned with learning goals - Practice over memorisation
L5	Create repayable micro-content
	<ul style="list-style-type: none"> - Content in small, manageable units - Learning should match time available - Open-ended learning - Foster repetition till proficiency, via replayability
L6	Consider appropriateness
	<ul style="list-style-type: none"> - System unobtrusive and persistent - Learning data accessible and transferable - Content appropriate for the subject matter - Content relevant and with real-world application

Table 5-11: Learning design guidelines for mGBL

The second set of guidelines presented on Table 5-12, is made up of five criteria which can be used to assess engagement in a mobile learning game application. These criteria include the ability of the game to provide challenge and feedback, to foster interaction, to promote stimulation and to feature adaptability.

E1	Game should provide challenge
	<ul style="list-style-type: none"> - Challenge appropriate to player skill - Challenge gradually introduced, increasing in difficulty - Foster feeling of winnability - Facilitate personalisation and/or adaptability
E2	Game should provide feedback
	<ul style="list-style-type: none"> - Feedback should be meaningful - Clearly indicate progress towards a goal - Show player status

	<ul style="list-style-type: none"> - Help functionality should be obvious
E3	Game should foster interaction
	<ul style="list-style-type: none"> - High level of interactivity - Encourage active participation - Interactivity in sync with pace
E4	Game should promote stimulation
	<ul style="list-style-type: none"> - Information processing via sensory curiosity - Understanding via cognitive curiosity - Story/Fantasy (where applicable) - Utilise humour (where applicable)
E5	Game should be adaptable
	<ul style="list-style-type: none"> - Difficulty adaptable to player skill - Gameplay personally relevant - Monitor progress and play patterns - Adjust system to individual player

Table 5-12: Engagement design guidelines for mGBL

The third set of guidelines presented on Table 5-13, is made up of six criteria which can be used to assess the usability and overall interface design of a mobile game-based learning application. These criteria include: the ability to support multiple contexts, the efficiency of the screen layout, the simplicity and easiness of controls, the responsiveness of the game, the clarity of goals and progress and finally the sense of control the player should have when using the system.

U1	Multiple contexts support
	<ul style="list-style-type: none"> - High contrast to enhance visibility - Font size comfortably readable - Gameplay should not rely on sound - Game playable with one hand
U2	Screen layout efficient, uncrowded and pleasing
	<ul style="list-style-type: none"> - Screen layout should not feel crowded - Required information always visible - Game should run in full-screen mode - Screen layout consistent between mini-games/levels/devices - Screen layout dynamically adjustable between orientations

U3	Intuitive controls
	<ul style="list-style-type: none"> - Controls intuitive and logical - Eliminate error-prone conditions - Navigation clear and consistent - Short navigation paths - Easy access to home/main menu
U4	Game responsive
	<ul style="list-style-type: none"> - Short response time to user input - Input recognition via feedback - Feedback provided on appropriate time - Clear that the game has ended
U5	Goals and progress clear
	<ul style="list-style-type: none"> - Short/long term goals clear - Short-term goals foster motivation towards larger goal - Choice over predetermined and player-driven goals - Progress towards goals monitored and/or comparable
U6	Player should feel in control
	<ul style="list-style-type: none"> - Obvious how actions affect gameplay - Quick recovery from errors - Support trial and error - Allow customisation

Table 5-13: Usability/UI Design guidelines for mGBL

The fourth and final set of guidelines presented on Table 5-14, is made up of six criteria which can be used to assess the game design of a mobile game-based learning application. These criteria include: mobile appropriateness, short play sessions, pick up and play, flexibility, rewards and visual design appropriateness.

G1	Design for mobile
	<ul style="list-style-type: none"> - UI assets optimised for mobile - Visual quality, for all screen resolutions supported - Touch-based controls over virtual control buttons - Design for speed and recovery
G2	Shorter play sessions
	<ul style="list-style-type: none"> - Design gameplay around short play sessions - Support long play sessions

	<ul style="list-style-type: none"> - Promote short-term goals
G3	Game easy to pick up and play
	<ul style="list-style-type: none"> - Game easy to learn (short or no tutorial) - Gradual on-boarding - Game quick to access and start
G4	Design for flexibility
	<ul style="list-style-type: none"> - Support interruptibility of gameplay - Integrate auto-saving - Return to previous game state, after pausing - Foster variable levels of difficulty
G5	Gameplay positive and rewarding
	<ul style="list-style-type: none"> - Ensure initial success - Short reward cycles - Rewarding rather than punishing mechanics - Foster the feeling of accomplishment
G6	Visual design appropriate
	<ul style="list-style-type: none"> - Visual representations recognisable and easy to interpret - Distinction between primary and secondary elements - Visuals uncluttered, sharp and inviting - Visual style consistent between mini-games/levels/devices

Table 5-14: Game design guidelines for mGBL

This chapter has described the steps undertaken to develop the design guidelines for mobile game-based learning. The above four sets of criteria can be used to assess elements of learning design, engagement, usability and game design which influence the appropriateness and overall effectiveness of a mobile learning game targeted at adults.

The next chapter will describe the design of the game prototype which was developed informed by the above guidelines and was later used to evaluate hypotheses via user testing.

Chapter 6

Designing Mobile Game-Based Learning

The evaluation of the effectiveness of a mobile game-based learning application, was one of the main aims of this research. In order to achieve this it was necessary to develop a game prototype designed to implement - as far as possible - best practices in mobile learning design. Therefore this chapter begins to discuss the next stage of the research, which involves applying the literature on mobile games and learning discussed in Chapter 2 (Literature Review) as well as the design guidelines for mobile game-based learning discussed in Chapter 5 (Developing Design Guidelines for mGBL), to the design and development of a fully functional game prototype. Further details on the development process will then be provided in the next chapter. The developed application entitled *Lexis*, is a mobile puzzle game for English academic vocabulary training.

This chapter initially examines the genres of mobile games that are more appropriate for learning as well as the learning areas most suitable to be supported by mobile game-based applications. From this initial discussion, focusing on language learning and more specifically vocabulary training was considered as a type of skill suitable to be supported by the developed game prototype. The second section of this chapter then looks into mobile assisted language learning as well as issues related to the design of vocabulary games. Finally the third section describes the design of *Lexis*, and more specifically the learning objectives, activities, theory and technology and provides an overview of the game.

6.1 Game Genre and Subject Area

In order to evaluate the effectiveness of a mobile game-based learning application it was decided at an early stage that the best approach would be to develop it from the ground up, instead of using pre-existing applications which were scarce anyway in this context. This approach would provide flexibility with regards regard to design

choices relevant to interface and functionality and would minimise any possible constraints of pre-existing applications. At the same time though, it would pose certain pragmatic limitations regarding the expertise needed and the time available. Therefore it was necessary to first consider the type of game that would best fit the context of mobile adult learning as well as the technical constraints of developing for mobile devices, and second to examine what types of skills might be most appropriate to be acquired via a mobile game-based learning environment. Subsequently, it would be possible to make an informed decision on the type of game application that would be most appropriate and could realistically be developed within the scope of this research.

Initial considerations were informed by the results of the background research as described in Chapter 4 (Background Study). According to this study, the majority of the survey participants indicated puzzle as their preferred mobile game type, while language was the most popular learning outcome indicated as suitable for mobile game-based learning. In addition the consideration of puzzle as a game genre well suited to the mobile gaming context was based on the case study analysis as described in Chapter 5 (Developing Design Guidelines for mGBL). Regarding the learning outcome, links between mobile and language learning are quite apparent in the literature as discussed later in this chapter. Taking all those aspects into consideration it became obvious that a puzzle game for language learning was an interesting direction to consider. It was however important to support this hypothesis via investigating existing research on game-based learning before making a final decision.

6.1.1 Types of Games for Learning

The first step was to investigate potential learning characteristics associated with different game genres. Since the aim was to overview genres commonly associated with game-based learning scenarios however, this investigation is not an exhaustive list of all possible game genres and subgenres. Talking about computer game-based learning in Higher Education, Whitton (2010) discusses seven distinct genres with regards to their educational potential, emphasising the possibility of overlapping

since individual games may fall into more than one category. These seven computer game types identified by Whitton are similar to the mobile game genres discussed in Chapter 2 (Literature Review). This is to be expected, since major game genres such as adventure, puzzle and strategy feature key gameplay characteristics that remain consistent between platforms and are often associated with play conventions independent from the medium of execution. Furthermore, although Whitton focuses on Higher Education, her distinction is still useful in the context of this research since learners in Higher Education are essentially adult learners and therefore share andragogical characteristics (Knowles, 1998) with the target audience of this research. A classification of game genres in the context of learning as proposed by Whitton, is therefore outlined below. The distinction is however that in the context of mobile gaming and according to the classification proposed in Chapter 2 (Literature Review), ‘Shooter’ and ‘Sports’ games are here merged into the ‘Action’ genre as a broader more inclusive category. This results in six game types described below:

Genre	Description	Learning Potential	Example Games
Adventure	Players undertake a series of tasks in which they must interact with the virtual world, perform actions, talk to characters and manipulate objects in order to achieve the objectives of the game, often to solve some mystery or complete a quest.	Context for problem-solving and lateral thinking (players have to work out the appropriate actions in order to achieve a goal).	The Longest Journey (1999), Syberia (2002), Heavy Rain (2010).
Platform	Involves the movement of the player character through a landscape, jumping up and down between platforms, avoiding obstacles, and picking up treasure, usually with some overall goal in mind and often in the context of a narrative.	Hand-eye coordination development, planning and strategising, problem solving and ability to think quickly.	Super Mario Bros (1985), Sonic the Hedgehog (1991), Trine (2009).
Puzzle	Involves problem solving, can take many forms (e.g. words, logic, mathematics). Simple puzzle games can be stand-alone or embedded within a larger narrative structure so	Support a variety of different types of learning depending on the type of puzzle (logic, verbal skills, numeracy skills, spelling, etc). Quizzes are included	Tetris (1984), Kirby’s Avalanche (1995), World of Goo (2008).

	that solving the puzzles will complete some larger quest or story.	in this category (primarily for the recall of facts).	
Role-play	Players take on the role of characters in another world. They can undertake a range of activities including solving quests, fighting, treasure hunting, and interacting with other characters.	Context for building collaborative skills, social interaction, negotiation, management of complex systems, strategy, and working through scenarios.	Fallout (1997), Deus Ex (2000), Dragon Age II (2011).
Action	Action games involve physical challenges. Popular sub-categories are shooting games, fighting games and sports games. They often involve the use of weapons to defeat enemies or simulate an activity.	Forward planning, strategising, and team working. Ability to practice an actual skill, tactics, rules and the ability to think and make decisions quickly.	Tomb Raider (1996), Halo (2001), Mirror's Edge (2008).
Strategy	Involve players making strategic decisions within a scenario in order to meet the goal of the game. They can involve movements of armies, progression of a group through various stages of development, management of resources or the creation of environments to achieve specific purposes.	Planning, decision-making, testing hypotheses, strategic thinking, management skills and seeing the consequences of actions taken.	Civilization (1991), Medieval: Total War (2002), Anno (2009).

Table 6-1: Types of games and their learning potential (adapted from Whitton, 2010, pp. 56-62)

Informed by the above classification, puzzle was considered an appropriate genre for the developed prototype, due to its learning potential of supporting almost any kind of learning outcome according to the design of the puzzle, as well as its suitability for the recall of information, which is useful in language learning. Specifically word puzzle games provide interesting opportunities in supporting language learning outcomes, as further discussed in the final section of this chapter. At the same time they are amongst the genres that fit the mobile gaming context well (Unger and Novak, 2012); even more so than some of the other types of games that although do exist on mobile devices, are not as popular or as fit for purpose.

The choice of genre is important in the game design process since it determines the kind of interactions the game will afford to players and helps to establish conceptual constraints for the designer. Game genres help to frame design conventions and play motivations that have formed for different types of games over time, and are relevant and meaningful to players. It was therefore important to look into the characteristics of the puzzle genre next and investigate how it could be implemented to support the research objectives and more specifically the game's learning objectives.

Puzzle games emphasise puzzle solving (Rollings & Adams, 2003), while they tend to base gameplay around logical or conceptual challenges. They focus on problem solving as the main in-game activity is often enhanced by action or time-based elements for additional immersion. Furthermore, puzzle games often do not include a fully developed narrative, though a simple backstory or some narrative cues may be encountered. Puzzle games can feature short play sessions and are often structured as collections of a series of related mini puzzles. Collections are not random however and are “usually variations of a single theme” (Rollings & Adams, 2003, p.487). Puzzle games usually feature a set of rules and players must achieve a victory condition to progress in the next mini puzzle. The order of mini puzzles that make up a collection can be linear (from the easiest to the most difficult puzzle), or allow the player to access the puzzles in any order. It is therefore important to define any possible connections between mini puzzles and make sure that they are meaningful. Puzzle games can be found in many varieties. Word puzzles have traditionally been used in language learning to help develop spelling and vocabulary skills and can easily be turned into successful games by adding interaction to the activity (Crawford, 1984). Mobile word puzzle games such as *Bookworm* (discussed previously in Chapter 5), can be quite entertaining and also provide an interesting potential for learning.

Puzzle games are particularly suited to the mobile gaming context and are widely popular on mobile devices. Their popularity is supported when looking at the case studies described in Chapter 5 (Developing Design Guidelines for mGBL), where five out of the eight games reviewed were primarily classified as puzzles.

Modern mobile puzzle game examples include *Angry Birds* (Rovio, 2009), *Bejeweled* (PopCap, 2007) and *Cut the Rope* (ZeptoLab, 2010). The suitability of puzzle games for the mobile platform however is also supported from a development perspective. Unger and Novak (2012) claim that: “due to their relatively straight forward design and limited pick-up-and-play sessions, puzzle games work quite well across all mobile platforms in single-player mode”. In addition to platform suitability, such games are well suited to casual gameplay where quick play sessions facilitate low attention demands and quick rewards. According to Trefry (2010), since such games are easy to start, pause and come back to, they don’t demand full attention right off, but ramp up their attention demands over time so players barely notice how fully they are engaged. For the purposes of this research it was therefore decided to develop a puzzle game because of its learning potential as well as its suitability for the mobile platform and casual gameplay.

Mobile puzzle games, though most often single player, are also quite popular in multiplayer mode. According to Unger and Novak (2012): “Synchronous, real-time online multiplayer puzzle games are quite common in smartphones – with upwards of 20 players simultaneously unscrambling words and answering trivia questions”. When evaluating a specific game genre for learning, it was therefore important to consider another important feature, which was the number of players. In the context of this research a single-player game format was adopted, due to the focus on personalised rather than collaborative learning. This decision was also informed by the results of the background survey as described in Chapter 4 (Background Study), where social games were indicated by participants as the least preferred type of mobile game, while social interactions, collaboration and sharing were identified as the least popular learning priority among adults. The decision was also informed by pragmatic constraints, since designing a single-player as well as a collaborative version of the game would not be realistic in the scope of a small-scale research project. Furthermore, recognising the importance of collaboration in the context of mobile learning, it was felt appropriate that a future research project could be entirely dedicated to the investigation of collaborative mobile learning games for adults.

6.1.2 Learning Outcomes

Having decided on the game type and the number of players, it was also important to consider the types of learning that could be facilitated with games. This way the suitability of the initially considered subject matter and learning outcome could be verified. Play has a powerful influence on learning and is fundamental to human development (Reiber, 1996); games can therefore be useful to teach a variety of skills, providing the opportunity to safely practice those skills in a controlled environment. Gee (2007) proposed a new kind of literacy that could be taught via games and identified thirty-six (36) ways in which games can support learning. Similarly Gagné et al. (1992) identified five categories of learning, which describe a range of skills, the development of which could be facilitated via computer games, and are presented below.

Category of Learning	Description
Verbal Information	Relating information both verbally and textually
Intellectual Skills	The use of concepts and rules to solve problem
Cognitive Strategies	Finding novel solutions to problems
Motor Skills	Physical movement of muscular components
Attitudes	Choices, beliefs and course of action

Table 6-2: Categories of learning (adapted from Gagné et al., 1992)

The above categories of learning, originally associated with computer games, also apply to mobile game-based learning which is suitable to support them all including motor skills due to handheld device affordances, mobility opportunities and hardware capabilities such as the accelerometer. Furthermore, Prensky (2001) discussed the relation between different learning content and game styles, suggesting that games can be used to support a variety of different types of learning.

Content	Learning Activities	Possible Game Styles
Facts	Questions, memorisation, association, drill	Flashcard type games, mnemonics, action games, sports games
Skills	Imitation, feedback, continuous practice, increasing challenge	Persistent state games, role playing games, adventure games, detective games
Judgment	Hearing stories, asking questions, making choices, feedback, coaching	Role playing games, detective games, multiplayer interaction, adventure games, strategy games
Behaviours	Imitation, feedback, practice	Role playing games
Theories	Logical experimentation, questioning	Open ended simulation games, building games, constructing games, reality testing games
Reasoning	Puzzles, examples	Puzzles
Process	Explanation, practice	Strategy games, adventure games
Procedures	Imitation, practice	Timed games, reflex games
Creativity	Play	Puzzles, invention games
Language	Imitation, practice, immersion	Role playing games, reflex games, flashcard games
Systems	Understanding principles, graduated tasks	Simulation games
Observation	Examples, doing, feedback	Concentration games, adventure games
Performance	Memorisation, practice, coaching	Role playing games, reflex games

Table 6-3: Types of learning and game styles (Prensky, 2001)

In the context of this research it was felt appropriate to focus on learning outcomes that involved the development of skills, reasoning, language and to focus on aspects such as problem-solving, association, continuous practice and the recall of facts, thus testing the application of intellectual skills and verbal information. Such learning outcomes were also supported by a behaviourist approach to learning, according to which the mobile game prototype was developed as discussed later in this chapter.

In this context, puzzle was still an appropriate game genre to consider. In addition reflex games (see Glossary) also appeared appropriate to support language and continuous practice, and it was therefore decided to incorporate reflex game mechanics in the form of time counters or word spawners in gameplay (see Chapter 7 for more information on game mechanics development). According to the above classification other game genres were also appropriate to support the selected learning outcomes such as adventure or role-play games; however it was felt that these genres were a better fit with computer rather than mobile gaming. This is because of the nature of computer games that could better support the development of high-level cognitive skills of application, analysis, synthesis and evaluation (Bloom, 1956) via longer and non-interruptible play sessions where the user would be able to learn in a predetermined, non-mobile setting. On the contrary, skills development and continuous practice were considered more appropriate to be supported by the mobile gaming context of shorter, interruptible play sessions occurring in spaced intervals, where users learn independently, embedding learning into their everyday life.

The final decision was therefore to develop a puzzle game to support skill development of a specific language competence such as vocabulary, instead of an adventure or role-playing game to fully teach all elements of the language including reading, speaking and writing. More specifically a game to support non-native English speakers to develop their academic vocabulary was the selected learning outcome. English academic vocabulary was perceived as suitable for adult learners interested in enhancing a specific sub-set of their existing vocabulary, in order to strengthen their speaking and reading comprehension in either an educational or a professional setting. It was therefore felt appropriate to create a game that was able to support learners to develop their knowledge of the meaning of academic words, use them in context and associate them with other vocabulary, so as to enhance their understanding and build associations. In addition to being seen as an appropriate topic to be learned via a mobile game, language learning outcomes would be highly transferable to everyday life. Furthermore, the content could be diverse enough to be appealing to both students and professionals, thus assisting pragmatic considerations

such as expanding the pool of possible user testers to be recruited at the evaluation stage.

Finally, since the application to be developed involved language and specifically vocabulary training, it was next important to consider certain issues associated with language learning in a mobile context. The following section will therefore briefly examine key issues regarding mobile language learning and vocabulary training as well as discuss mobile games for vocabulary development.

6.2 Language Learning Games

This section will discuss some of the issues that emerge when considering the implementation of vocabulary development mobile games. Initially, mobile assisted language learning (MALL) will be introduced. Then, issues associated with the training of academic English vocabulary among adult language learners will be overviewed. Finally, possible opportunities for the use of mobile games for vocabulary development will be discussed, including motivation, transfer, memory, association, attention and micro-content.

6.2.1 Mobile Language Learning

Although mobile learning is not in itself new, the steady evolution of the technical capabilities of contemporary mobile devices has led to increasing interest in various academic fields including language education. However, evolving technology is often linked to evolving social practices and the massive adoption of mobile devices by contemporary adults today implies several strengths. Mobile phones and tablets are lightweight and always accessible, allowing learning to take place anytime and in any location, thus providing an opportunity for waiting, commuting or idle times to be utilised in a meaningful manner. Additionally, such devices are personal which means that they are owned by individual users and are highly customisable to their individual needs.

The potential of mobile learning is summarised by Kukulska-Hulme (2009) as the opportunities it provides for learning that is personalised, situated, authentic, spontaneous and informal, while it can also support quick feedback, access to information while moving, record keeping in informal learning settings and immersive experiences such as mobile investigations and games (Kukulska-Hulme et al., 2009). Such potential is key to effective language learning and constitutes mobile devices suitable for individualised informal learning associated to the learner's life outside formal education.

Mobile assisted language learning (MALL), which is language learning assisted or enhanced via the use of mobile devices, is a relatively recent research area (Vavoula & Sharples, 2008), which is currently evolving. The major difference between MALL and traditional language learning is the element of mobility coupled with the possibility of spatial and temporal shifts (Kukulska-Hulme, 2009). MALL therefore brings a major opportunity of shifting the time and space constraints of formal language education, begging for innovative, flexible and informal learning scenarios since the nature of mobile learning can only be fully understood when observing its usage in naturalistic settings different from the artificial environment of the classroom (Stockwell, 2010). Such opportunities have led Kukulska-Hulme (2006) to predict that language learning will be a fruitful area of informal learning with mobile devices. The present research therefore looks into how mobile technology can support the development of language learning skills in contemporary adults' daily informal environment. *Lexis*, the developed vocabulary learning game prototype is aimed to be used independently from formal language education, in a learner-directed way.

Research on mobile assisted language learning has been wide-ranging, with various studies focusing on a number of devices such as mobile phones, tablets or even PDAs, which have been found to promote the creative learning of idioms (Wong & Looi, 2010). Studies with phones have also focused on a range of language learning areas including evaluating learner preferences and attitudes towards MALL (Stockwell, 2007) and fostering grammatical accuracy (Baleghizadeh & Oladrostam,

2010). Many applications focus on specific elements of language learning such as improving speech fluency (Kessler, 2010), using SMS messages to send vocabulary to learners (Lu, 2006) and offering short quizzes, which are available to download or access (Chinnery, 2006). Increased mobile technology capabilities have also marked the emergence of more innovative approaches of MALL, inspired by the enhanced functionality of devices. Pemberton, Winter and Fallahkhair (2009) discuss 'Cloudbank' and how it utilises crowdsourcing and client-server relations on mobiles to develop a database of informal English language usage, keeping users informed via RSS feeds. Another interesting project, 'Micromandarin' (Edge et al., 2011) utilises the application Foursquare to provide contextually relevant vocabulary to language learners via GPS technology. Many types of MALL applications exist, such as flashcards, dual language dictionaries and phrase books and more recently multimedia applications and those applications that utilise mobile phone capabilities. Mobile games however, although occasionally present in research (Todd & Tepsuriwong, 2008), are far less frequent in comparison to other types of mobile language learning applications.

In the case of this research the focus is on vocabulary training, based on a mobile game-based learning approach. The next section will therefore begin by discussing English academic vocabulary for adult language learners, before focusing on mobile vocabulary learning games in the following section.

6.2.2 Academic English for Adult Language Learners

English is an international language of increasing importance for global communication, business, research and entertainment. Learning English is very popular in many non-English speaking countries while the language is often considered as a key skill for educational and professional purposes. It therefore becomes obvious that research focusing on developing effective language learning tools for English language education is critical in today's world.

English for academic purposes is a specific sub-set of English language education aimed at assisting language learning needs in an academic setting and more specifically research, study or employment in academia. As a language, English is particularly important when it comes to academic purposes since according to research, the growth of English as a learning language for the dissemination of academic knowledge has a major impact in associating scholars' careers with their competence in the language (Graddol, 1997). English now appear to be the world's predominant language for research and scholarship, while more than 90% of journals in certain scientific domains are printed in English (Hyland, 2006). Furthermore, there is evidence that many doctoral students choose to complete their Ph.D theses in the English language, when they can (Wilson, 2002). It becomes obvious therefore that mastering academic English is essential for scholars, researchers, academics and students in order to establish their careers or to successfully complete their education. However, it is argued here that academic vocabulary is an essential part of academic English language learning, for both academia and the workplace and can support the effective reading, writing and communication skills of a number of students and professionals in either an academic or industry environment.

In the case of this research project the learning objective for the game prototype *Lexis* is the training of academic English vocabulary. It is therefore necessary to distinguish between English for General Academic Purposes (EGAP) and English for Specific Academic Purposes (ESAP). In the case of EGAP the focus is on language skills thought to be common in all disciplines, while for ESAP the focus is on language that is relevant to the demand for a certain discipline or department (Hyland, 2006). For this study the focus is on EGAP, and an argument is made that prior to moving on to learn specific academic vocabulary, adult language learners should first familiarise themselves with general academic purpose words. It is also argued that EGAP vocabulary although more general is often less straightforward to understand and use in comparison to discipline specific vocabulary, while it is also transferable across contexts. Finally, a good command of English vocabulary for general academic purposes may support a whole range of activities including writing essays, making and summarising arguments, presenting, listening to and

understanding lectures, reading texts, taking notes, participating in seminars and tutorials, conducting library searches for resources according to relevance, etc.

When discussing any type of English language education however, it is important to distinguish between child and adult language learners since their needs may be quite different. Adult learners are usually looking to learn a new language to address a demand such as to follow a career opportunity, to pursue education or to fulfil personal or family needs. A common reason that may lead to the decision to learn a new language may include adults being immigrants, professionals or students in another country. Not surprisingly therefore, adult language learners are often more goal oriented, looking to set their own learning objectives to achieve relevance and quick value from their studies. Adult language learners also tend to have greater cognitive and linguistic capabilities such as a greater attention span and memory storage capacity, in comparison to younger language learners (Robinson, 2005). Different language learners may prefer different learning approaches such as active learning, experimental problem solving, or fact recall and memorisation, although the ideal learning method really lies with the individual. According to Cohen (1998), the way learners apply strategies depends on a variety of factors including their individual preferences, personalities and tasks and may vary greatly. It therefore becomes apparent that an independent, individualised and adaptable system, able to support specific learning needs, could be of great potential amongst adult language learners.

Any language learning can be divided into four main components, which are listening, speaking, reading and writing. However, there is an argument to be made that vocabulary is an essential part of language learning as well and is useful in supporting all of the above components and especially reading comprehension. According to Wilkins (1972), “without grammar very little can be conveyed, without vocabulary nothing can be conveyed”. When it comes to the English language, vocabulary learning is a very important issue and its importance should thus be emphasised (DeCarrico, 2001), since an excellent vocabulary is essential to infer correct meaning from sentences written in English (Harmon, 2002).

According to Nation (1990), to read English with fluency, a language learner should understand at least two thousand commonly used words. Apart from reading comprehension, vocabulary is also key in communication either written or spoken, since minimal vocabulary is insufficient for effective communication. It therefore becomes apparent that vocabulary training is an important part of the learning of the English language. Huckin, Haynes and Coady (1993) emphasise the importance of reading ability and vocabulary knowledge and indicate them as the two most important components of good performance in a second language, which depend on one another.

When it comes to vocabulary acquisition and training, technology is increasingly becoming an important learning tool. Computer assisted language learning can effectively support memorisation skills via the use of mnemonic mediators for the meaning of words, as well as facilitate drill, practice and testing to assist the language learner's retention (Ellis, 1995). Mobile assisted language learning (MALL), as discussed above, is a key strand in vocabulary training research, since it effectively combines the learning potential of both mobile learning and computer assisted language learning, providing opportunities for flexible and accessible learning free from spatial and temporal constraints.

Focusing specifically on mobile games as the medium for the facilitation of MALL, the next section will discuss the possible benefits that games bring in assisting vocabulary development.

6.2.3 Mobile Games for Vocabulary Development

Games have long been used as a key component of language learning instruction in various contexts, from sentence building exercises to conversational role-playing. Mobile game-based learning supports connections between language vocabulary development and games since the association between mobile learning and mobile gaming is already strong and appears to be getting stronger (Kukulska-Hulme, 2009).

At the same time, according to Smith (2008), a word rich environment is key to increasing vocabulary usage and reading fluency. Mobile games can therefore provide immersive experiences, and are able to assist vocabulary building via allowing the learner to take an active role while playing the game and mastering at the same time the vocabulary-based content. Furthermore, the use of mobile games for vocabulary development brings interesting learning opportunities inherited by the nature of the medium, which combines the accessibility of mobile learning and the motivational strengths of game-based learning. Following, such opportunities of mobile games with regards to vocabulary training are further discussed.

Motivation

Motivation is key when it comes to language learning. According to Krashen (1981), language learning programs have to be highly motivating and designed in such ways to cause learners to forget they are dealing with another language. Especially for adult language learners, the issue of motivation is important, since they often deal with the challenge of maintaining their motivation while facing the various demands of everyday life and work. It becomes obvious therefore that motivation is one of the most important factors of successful language acquisition (Krashen, 1981: 1982). Games can help to attract and retain motivation while learning takes place; and although no one type of game can appeal to everyone, there are some factors that contribute to intrinsically motivating instruction including performance feedback, personally meaningful goals, uncertain outcomes, scorekeeping and randomness (Malone, 1984). According to Malone (1984), motivation can be increased even further via personalisation. This implies a game environment that fosters variety in gaming experiences and is based on the individual's actions. This is particularly important to language learning and more specifically vocabulary development, since a game system can be adaptable to the individual skill, pace and learning objectives via facilitating a safe and engaging environment able to support personal learning needs. Mobile games can thus fit learning designs that are personalised, accessible and highly motivational, and they therefore become a strong medium for the effective vocabulary development of adult language learners.

Transfer

One of the main issues in learning is the promotion of transferable skills (Bransford, Brown & Cooling, 2002). This is a major consideration when it comes to designing games for language learning since the goal is for the user to transfer newly learned words to everyday vocabulary. Educational games in general can create opportunities for transfer since the knowledge and skills acquired can help learners to apply the conceptual knowledge to other situations or settings. Mobile games for vocabulary development can support the transfer of both the game content (new vocabulary) to situations where language is used (e.g. reading comprehension), as well as the gameplay concept (e.g. principles and rules of the game) to new settings where such concepts may be required (e.g. problem-solving). Mobile games can therefore facilitate transfer via supporting the application of vocabulary knowledge to practical activities where language is required. At the same time, learners can test the way new words are used and associate them with other words via trial and error in the game environment, before using them in real life contexts.

Memory

One of the main problems in vocabulary acquisition is the loss of acquired information over time, or forgetting newly learned words. Successful vocabulary development games should therefore incorporate mechanics for the effective recall of information to assist the learners' memory. Oxford (1990) indicated types of memory enhancement strategies including applying images and sounds, reviewing and employing actions. Typically, information recall is better just after learning new vocabulary rather than after a long delay since memory is gradually lost. Often repetition as a memory enhancement strategy is therefore essential to enable language learners to retrieve information when needed. Repetition also ensures that the learner comes across a word more than once. Repeated encounters with new vocabulary can assist the learner's understanding of how and when to use the word. Mobile games offer a fruitful platform for the application of memory enhancement strategies since principles of spaced repetition can easily be built in play sessions.

Via this technique, repetition of new words to be remembered can be programmed to occur in spaced intervals during gameplay, thus minimising the chances of forgetting. Furthermore, long-term memory in mobile game contexts can be supported via spaced notifications in the form of reminders featuring vocabulary taken from a pool of words that the learner finds difficult to remember.

Association

When it comes to vocabulary training the association of meaning is a key consideration. The language learner needs to be able to understand the meaning of the word as well as how the word relates to other words. Research has shown that vocabulary learning can be enhanced by providing learner friendly definitions for individual words (Graves, 2008). Such definitions are easy to understand and help the retention of new vocabulary. Additionally, it is essential for vocabulary building that words are not learned as stand-alone but in connection to other words (Young, 2005). In a mobile gaming context, association can be fostered via a variety of combined word activities organised in mini-level architecture. Such activities could include identifying word families, synonyms or making collocations. Puzzle type and word games can be especially relevant to this context as they allow for verbal skills acquisition and help to train logic, spelling and the recall of facts.

Attention

One important benefit of mobile games with regards to language learning is their attention enhancement possibilities. Contemporary mobile devices tend to focus the attention of the user on a single task at a time. This is due to their interface design, since although they provide opportunities for multitasking they tend to exclusively focus attention on the running application (in full screen mode); this is not usually the case with computers. Attention enhancement is also supported by the fact that mobile game sessions are usually short and therefore the user's focus on the task is not required for a long time. For learning purposes and especially for vocabulary training, this can be beneficial as the game may attract the user's full attention even

for a short period of time, maximising the learning that will happen during this time span. Assuming that such short and full-focused sessions will often take place in intervals, learning can be achieved in an optimal manner for the mobile context.

Micro Content

As discussed in Chapter 2 (Literature Review), mobile game-based learning contexts are particularly suitable for microlearning. The mobile device can become the platform for microlearning (Gessler, Hung and Glahn, 2004) and the game can become the tool to achieve the learning of small units of content, in an effective and pleasant manner. This type of learning is particularly interesting in the context of vocabulary development for adult language learners, who as previously discussed in this chapter need independent, flexible and individualised learning solutions. It also aligns with the attention grabbing opportunities of mobile learning games, since it allows the exploitation of short time spans, during which distractions are temporarily paused and the adult can focus on vocabulary training for a few minutes. Mobile devices are also suitable for microlearning due to portability which makes content easily accessible and usable on demand. Mobile vocabulary development games in particular can facilitate effective microlearning via summarising the learning content covered during a play session, allowing practice via quizzes or mini-games, assisting recall via spaced reminders and allowing immediate support and access to content when there is a need for it.

Having looked at the benefits of using mobile games for vocabulary development, the next section will move on to discuss the design of the game prototype that was developed as part of this research project. The game, entitled *Lexis*, is a mobile English academic vocabulary training game, targeted at adult learners.

6.3 Designing Lexis

In this section the next important contribution of this research is discussed in detail. This was the implementation of the *Lexis* mobile game prototype, which has been informed by the design guidelines presented in Chapter 5 (Developing Design Guidelines for mGBL). Having already looked into the game genre and subject area above and discussed the issues around mobile games for vocabulary development, the rationale underlining the design process of *Lexis*, is presented here. Learning objectives and content, the overarching learning theory, technology considerations as well as features and functionality of the game are all discussed below.

6.3.1 Learning Objectives and Content

As discussed previously in this chapter, the selected subject area for *Lexis* was language learning. The learning objective was the development of English academic vocabulary skills for adult language learners, who were non-native English speakers (speakers of English as a second language). It was decided not to focus the gameplay towards an explicitly defined level of language competence, since learner classifications would be hard to monitor and evaluate later without contributions from language experts. Additionally, since the aim for the game was to be developed as an adaptive system, able to customise the content difficulty according to player performance, it could be used by different learners with non-unified levels of vocabulary competence. Finally, the game prototype was primarily intended as an experimental apparatus for research hypotheses evaluation and was therefore not intended as a sophisticated, verified language learning tool based on the Common European Framework of Reference for Languages (CEFR), which describes the achievements of learners of foreign languages across Europe. As a general categorisation, *Lexis* was addressed to intermediate language learners, since at a beginner level academic vocabulary and the meaning of relevant terms would predictably be far too challenging. As an academic vocabulary development tool therefore, the game was designed to help non-native speakers of English who had a conversational command of the language, to enhance their understanding of more complex terms.

A further objective was to utilise general and non-discipline specific vocabulary, which could be used by both academics and professionals and which was at the same time specific enough to be implemented. After all, as described in the previous section on language learning games, the focus was on English for General Academic Purposes (EGAP). The final learning content for *Lexis* was the sixty (60) most common academic words according to Coxhead's (2000) Academic Word List (AWL). The Academic Word List was developed by Averil Coxhead at the School of Linguistics and Applied Language Studies at Victoria University of Wellington, New Zealand and contains 570 word families, which appear with great frequency in a broad range of academic texts. These word families are further divided into 10 groups, where the words of the first group are the most frequent; the 60 words used for the game therefore are the most common academic words and belong to the first group of the AWL. These words are presented below:

ANALYSIS	ESTABLISHED	OCCUR
APPROACH	ESTIMATE	PERCENT
AREA	EVIDENCE	PERIOD
ASSESSMENT	EXPORT	POLICY
ASSUME	FACTORS	PRINCIPLE
AUTHORITY	FINANCIAL	PROCEDURE
AVAILABLE	FORMULA	PROCESS
BENEFIT	FUNCTION	REQUIRED
CONCEPT	IDENTIFIED	RESEARCH
CONSISTENT	INCOME	RESPONSE
CONSTITUTIONAL	INDICATE	ROLE
CONTEXT	INDIVIDUAL	SECTION
CONTRACT	INTERPRETATION	SECTOR
CREATE	INVOLVED	SIGNIFICANT
DATA	ISSUES	SIMILAR
DEFINITION	LABOUR	SOURCE
DERIVED	LEGAL	SPECIFIC
DISTRIBUTION	LEGISLATION	STRUCTURE
ECONOMIC	MAJOR	THEORY
ENVIRONMENT	METHOD	VARIABLES

Table 6-4: Academic Word List (AWL) – Group 1 (Coxhead, 2000)

The specific intended learning outcome of the game therefore, was for the learner to gain an understanding of and practice the selected vocabulary. Based on the above list of academic words, game activities were designed to support adults towards the following learning objectives:

1. Familiarise with the vocabulary and learn the definition of each word.
2. Understand how to use each word in context.
3. Develop word association skills and learn how to spell each word.

Lexis thus provided an environment to support the above learning objectives and helped learners to build their skill on the selected vocabulary, therefore being therefore useful for both learning as well as reviewing vocabulary. Furthermore, according to casual mobile gameplay values the game was developed to be replayable, aiming at supporting vocabulary development over time. Game activities were designed to fit primarily shorter play sessions, without however excluding the possibility for continuous play over longer periods of time. The game was developed as single player, while content difficulty and progress monitoring were dynamically adapted to the individual learner.

6.3.2 Puzzles as Vocabulary Learning Activities

To support the aforementioned intended learning objectives it was decided to divide gameplay into three mini-puzzle games. This way the overall aim, which was vocabulary development and training, could be best facilitated by each mini-game targeting one specific learning objective via appropriate mechanics. Utilising a mini-game for each objective was considered as an appropriate way of designing *Lexis*, since it would allow players to focus on a specific task and build a given skill; learning the meaning of a word, using it in context, or associating it with other words and spelling it. Furthermore, as discussed in the previous chapter, this type of mini-level architecture was well fitted to mobile game design and allowed for shorter play sessions as well as the introduction of a gradual increase in difficulty. According to Rollings and Adams (2003), puzzle games are often structured as collections of related mini-puzzles, which are variations of a single theme. In the mobile context,

mini-games can facilitate microlearning by allowing the division of content into manageable chunks. Furthermore, a series of puzzles, each targeting a specific learning goal towards a larger learning objective, can assist scaffolding especially when mini-games utilise the same content in increased difficulty activities.

Puzzle design in each mini-game was heavily influenced by existing activities used to teach language skills, since word puzzles are often utilised in language education. Traditional pen and paper language puzzles such as choosing the right word, filling the gap, matching words to definitions, making a collocation and word substitutions or anagrams, can often be employed for vocabulary training (Porter, 2007; Cullen, 2008). Pen and paper word puzzles however can be enhanced by game mechanics, since the activity then becomes interactive. It is this interaction that makes the activity a game rather than a puzzle, since puzzles do not actively respond to a player's moves (Crawford, 1984). Designing game activities informed by existing language puzzles therefore would bring dual benefit. On the one hand, utilising a common vocabulary learning strategy and on the other, converting this strategy into an interactive game. Furthermore, this design decision brought the additional benefit of familiarity based around the idea of transference, which according to Lieb (1991), can occur via association (presenting game activities in known formats), similarity (revisiting logical puzzle patterns) and degree of original learning (utilising previous familiarity with vocabulary training puzzles).

The suitability of word puzzles as vocabulary learning activities can be supported by research on instructional strategies for vocabulary training. A key element to increasing vocabulary learning is providing concise definitions for individual words (Graves, 2008). A mini-game to introduce words and concise definitions was therefore considered a good starting point to help build vocabulary skills and support the first learning objective. Providing concise definitions could also support scaffolding, which can be succeeded via simplifying the language and making it easier to understand (Bradley & Bradley, 2004). However, second language vocabulary acquisition can become more effective through a variety of vocabulary-enhancing activities (Coady & Huckin, 1997). Additionally, it is important for words not to be learned as stand-alone items but rather with connection to other words (St.

Clair Otten, 2003). Furthermore, according to McKeown and Beck (2004), vocabulary instruction should offer multiple exposures to the target words, employing a breadth of information with varying contexts for target words and creating opportunities for learners to actively interact with word meanings. Providing multiple exposures to the selected vocabulary via mini-level architecture therefore, was considered effective to allow different opportunities to process the words through varying puzzle mechanics. In this context learning connections between words could be supported in the game environment, via activities such as using a word in a phrase or associating it with a synonym or antonym. This way new words could be introduced in context, not as sole definitions of meaning but in reference to other words, helping the learner understand how to use them in everyday communication.

Opportunities to process the meanings of words in various contexts can also occur via matching mechanics. Matching games often used for vocabulary training may involve the matching of words to definitions (understand meaning), to other words (make associations) or to missing word phrases (use in context) (Porter, 2007). Each matching activity can involve a pool of words the learner has to choose from, while the same words may be revisited in other activities to be used in different contexts. Matching mechanics are recommended as a vocabulary learning strategy in the literature (Stahl & Nagy, 2006; Beck et al., 2002). Furthermore, Bressan (1970) discusses two types of crossword puzzles which can be effective for language learning. These have to do with direct definition clues, which include generic, definitory and descriptive clues and cryptic clues which include anagrams, word inversions and so on (Bressan, 1970). Finally, asking for completion instead of generation, where the learner can choose between possible answers or complete a partially finished paragraph is a key mechanics for supporting scaffolding (Bradley & Bradley, 2004). With regards to vocabulary training however no one best strategy has been identified (Scarcella, 2003), instead the biggest impact comes from a combination of strategies, which explains the need for multiple opportunities to process words. Informed by the above literature, the design of *Lexis* utilised matching and completion mechanics, as well as both direct definition and descriptive clues. The use of mechanics variation in the game allowed for multiple exposures to

the selected vocabulary and was therefore perceived as an effective way to support learning.

Lexis was designed for replayability, where practice would be facilitated via short and often play sessions. Replayability is key to retention since according to August et al. (2005), increased practice time is required for new vocabulary. Repeated encounters with words via frequent practice means that learners work with the same words more than once and can build their skill over a period of time. Repeated exposure can help develop an understanding of when it is appropriate to use the word (Phythian-Sence & Wagner, 2007). Based on the assumption of incremental word knowledge building (Stahl & Nagy, 2006), *Lexis* was designed to allow for regular practice with the target words via repetition of play. In a mobile microlearning context, learners can build their vocabulary via spaced repetition. According to this method, learning is better when the content is presented over time (Godwin-Jones, 2010). In this context, retention can be achieved via learning in spaced intervals before the new vocabulary is likely to be forgotten.

Informed by the above instructional theory, the initial conceptualisation of the three mini-games that made up *Lexis*, is presented below:

Mini-Game	Learning Objective	Puzzle Mechanic
Word Pick	Understand the meaning of the word	Match definition provided to appropriate word
Phrase Gap	Use the word in context	Fill the gap with the appropriate word
Letter Spell	Make association between word and synonym	Recognise the word via the synonym provided and spell it

Table 6-5: Initial conceptualisation of the three mini-games

The overall design aim was to develop these three-mini games based on existing word puzzle activities used for vocabulary training, with each targeting one of the intended learning objectives and thus providing support towards the larger learning goal of vocabulary development.

The design of the above mini-games aligns with vocabulary instruction principles discussed earlier. Further particulars on the development of the three mini-games will be provided in the following chapter, where the extent to which the prototype matched the design guidelines proposed in Chapter 5 (Developing Design Guidelines for mGBL) will also be discussed.

6.3.3 Language Learning Theory

Theories of learning play an important role in the design of learning applications. Although various theories of language learning exist, a behaviourist approach was adopted for the design of *Lexis*, as briefly discussed in Chapter 2 (2.4 Mobile Game-based Learning). A behaviourist approach to learning seemed appropriate for the context of informal mobile microlearning, where a puzzle game was employed for the development of English academic vocabulary. Behaviourism also supported the subject area and learning objective well, as discussed earlier in this chapter, and was therefore considered appropriate for vocabulary development via mini puzzle games.

According to Skinner (1957), the behaviourist approach suggests that language can be learned explicitly via repetition and memory, since it is a habit-associated activity. This approach can be well suited to certain aspects of language development skills like vocabulary. Mobile devices can enhance the behaviourist learning process since they can be utilised to present the learning content, get the user's response and give appropriate feedback, which then provides reinforcement. Behaviourism describes that learning can happen when a correct response is demonstrated and its strength is therefore when the learners focus on a clear goal where they can respond automatically to the cues of that goal, realising the learning objective (Zaibon & Shiratuddin, 2010). Each of the mini-games of *Lexis* is thus designed to target a clear goal, towards the overall learning objective of the activity.

Despite a move away from behaviourism, this approach has lost none of its momentum in transferring to the use of mobile devices (Naismith et al., 2004). According to Traxler (2005b), mobile games tend to favour a model of learning based around the behaviourist drill and practice. This is because mobile devices can be excellent for drill and practice exercises, especially since feedback can be almost immediate (Nordin et al., 2010). “Drill and feedback” mobile activities provide two major benefits which include content that can be tailored to particular needs and the valuable collection of data about the progress of individual students (Naismith et al., 2004). In that direction, mobile devices can support the behaviourist approach via offering self-paced, personalised learning, which is adaptable to the needs of the individual learner who can direct their own learning whenever and wherever they choose.

Looking at the adaptability of learning theories to mobile game-based learning, Zaibon and Shiratuddin (2010) summarised two main advantages of behaviourism for mobile learning games; these are the concept of repetition and reward and a place for practice through repetition while receiving rewards for each proper response. Furthermore, they presented four characteristics of behaviourism in the development of mobile game-based learning, which have been adopted for the design of *Lexis*. According to Zaibon and Shiratuddin (2010), these are: stating objectives and breaking them down into steps (which in *Lexis* has been achieved via the mini-games architecture), providing cues that guide players to desired behaviours (hints mechanics have been implemented in the third mini-game), using consequences to reinforce the desired behaviour (achieved via scores, lives and bonuses) and finally providing good feedback to players (immediate feedback has been implemented for all games).

It is important to note that not all language skills are appropriate to be acquired via behaviourist learning frameworks, since fluency may require blended approaches and considerable exposure to the language. As previously discussed in this chapter however, *Lexis* was developed to assist vocabulary development and not to fully teach the language from all linguistic aspects. Furthermore, language learning is not a unified activity since the separate functions of speaking, listening and writing have

to be addressed (Pemberton, 2002), and there is no single position of how a second language is learned (Mitchell & Myles, 1998). A level of freedom therefore exists in selecting a suitable approach according to context, platform and intended outcomes.

Offering a personalised experience via content that can be tailored around the individual learner is a major benefit of the behaviourist approach, but also a key element of effective mobile game-based learning according to the design guidelines presented in Chapter 5 (Developing Design Guidelines for mGBL). Personalised experiences in games can be achieved via adaptability, an important element of engaging learning, as proposed in the previous chapter. Despite the possible benefits of adaptive mobile learning games for language however, such cases are scarce primarily due to the development costs and expertise required for authoring such a system. There is therefore a need for more examples of adaptive mobile games especially since in consideration of the growing popularity of casual games there is increasing interest in how education and personalisation can be applied to reach a broader spectrum of game-based learners (Peirce & Wade, 2010). *Lexis* was therefore developed to be adaptable to the individual learner (further game specifications will be discussed in Chapter 7: Developing Mobile Game-based Learning). The game features adaptation in the form of adaptive challenge difficulty with appropriate feedback as well as individual player performance information gathering.

6.3.4 Technology

As discussed at the beginning of this chapter, for the purposes of this research a game prototype was developed from the ground up to allow for flexibility of design. The researcher therefore undertook the interface design and programming of the game. Though flexible however, this approach posed certain pragmatic limitations and thus the evaluation of technological constraints was necessary. The aim for *Lexis* was to be developed for the mobile platform and to be tested on widely available devices. It was therefore important to decide which device to design for, since universal compatibility for all mobile operating systems was not a realistic objective for a small-scale research project.

The choice was primarily between targeting either Android or iOS devices, however iOS was selected for practical reasons relevant to the researcher's design experience as well as the available workstation for development, which consisted of an OS X laptop and an iOS mobile phone.

An additional consideration was the choice between a native or web (non-native) application. Native applications are those developed targeting a particular device which are built to run on the device's operating system, in comparison to web applications which are designed to run on the device's web browser. Both types come with benefits and challenges, however it was finally decided to develop a native application for iOS. This method would allow for better performance and the application would be available to use offline, therefore eliminating the need for web access while playing. Furthermore, a native application would allow easy access to device features if needed, either at this or at a later stage of development, in the event of future expansions. This decision was further supported by the fact that the developed application was a game and therefore user experience was a priority. Finally, at the time the decision between developing a native or web application was made (mid-2012), web applications and the technology supporting their development were not considered mature enough to support the creation of a mobile game. Two considerable drawbacks in developing a native application however were device specificity and certification from a third party. At the start of the development the running iOS version was iOS 5, targeting iOS 6, which had already been announced. By the time the development had finished and the final user testing had taken place, iOS 8 had been released. This rapid evolution of operating systems, as is the case with mobile technology, did pose certain challenges which had to be addressed.

Once the decision was made to develop a native application for iOS, the development platform had to be selected. After consideration and research, Unity was selected. Unity is a game engine with authoring capabilities, commonly used for developing interactive games for various platforms. At the start of the development the mobile exporters for Unity had been released, which made native development for iOS mobile devices feasible. The mobile exporters allowed building and running the game directly from Unity to a mobile device via Xcode, Apple's integrated

development environment (IDE) for developing software for OS X and iOS. Furthermore since Unity is a sophisticated game engine, it supported the development of a game application and allowed for an optimised user experience and a polished user interface. An additional benefit of using Unity was graphics quality, as well as both 2D and 3D graphics support for mobile. The final decision however was to develop a 2D game due to the selected game genre style as well as the better utilisation of the hardware resources of the phone. This decision was further supported by the release of Unity 4.3 in early 2013 (soon after the development of the prototype had begun), which featured native 2D development tools. These embedded 2D development tools made the creation of a mobile game featuring 2D graphics more feasible.

Another reason Unity was chosen was because of its developmental and programming model, which allowed for the simplification of certain game development actions. An additional attractive feature was UnityScript used in Unity, which is closely related to JavaScript and allows efficiency and generation of less code. The researcher's previous familiarity with JavaScript to the point of being able to conduct self-training to build the skills needed to develop the game prototype, was an additional benefit of using UnityScript. Finally, research of different development tools suggested that Unity was suitable to accommodate the needs of the project, which although it would be significantly smaller than a commercial mobile game it would still become a quite a large project by research prototyping standards. Unity was therefore an all-around suitable tool for dealing with the complexity of the project.

6.3.5 Game Specifications

Lexis is a single player game, designed to meet the learning objectives described previously in this chapter and to be as game-like as possible according to the game characteristics provided in Chapter 2 (Literature Review). The game was designed as a collection of three related mini puzzle games, which provided a virtual space for players to navigate and interact in, offering measured outcomes via scoring, reward systems and monitoring of progress. Here the design of the game is overviewed,

while more details on development and architecture will be provided in the following chapter (Chapter 7: Developing Mobile Game-Based Learning).

Utilising a Game Design Document (GDD) as the framework to discuss the design of a game is a common practice for commercial projects. Though various guidelines for the required sections of a GDD exist in literature a universal document structure applicable to all games is not available. Often the purpose of the GDD is to describe gameplay, story, characters, UI, game architecture, art, target audience, etc. (Bethke, 2003). Furthermore GDD design guidelines usually apply to entertainment video games and thus no particular standard exists for mobile learning games. The majority of GDD therefore could include variations of sections proposed in game design literature.

Oxland (2004) describes eight elements that provide an overview of a game including: objectives, summary, character, user interface, structure, missions, environment, mechanics/AI, multiplayer interaction and sound. Bethke (2003) proposes five sections that should go into a GDD including: definition, gameplay, mechanics, story and assets. Finally, Rollings and Adams (2003) propose general sections, which include a number of sub-sections including: overview (e.g. concept, genre gameplay highlights, technology highlights, etc.), production details, competition and world (e.g. backstory, objective, characters, etc.). According to Oxland (2004) however, not all of these elements may be required in a design or additional ones may be used, since a proposed GDD is a template and some of the elements may not be relevant to all designs. Here a number of these elements have been employed, as felt appropriate for the game *Lexis*, and are utilised to provide an overview of the design:

Objective	Play all three mini-games and gradually improve performance.
Summary	The game is based on a series of related mini-games, which constitute variations of a single theme, that of interactive word puzzles. The three mini-games are <i>Word Pick</i> , <i>Phrase Gap</i> and <i>Letter Spell</i> respectively. Each mini-game's gameplay is based around problem solving, generally facilitated by selecting and combining elements. Puzzles are designed to address the

	individual learner, while game difficulty adapts to the skill of the player.
User Interface	<p>The user interface (UI) of the game enables users to:</p> <ul style="list-style-type: none"> - See an introductory screen featuring all mini-games - Select between mini-games to play - Read information on how to play each mini-game - See available lives, current score and time remaining - Access additional information about each game - Where available, receive hints on the current puzzle - Interact with active elements via tapping - Receive bonus lives for good performance - Get feedback for wrong answers - Navigate back to the introductory screen - See achieved score and high score at the end of gameplay - See visual performance indicator in the form of a star system - Choose to replay or change game - Access performance statistics for each game
Structure	<p>The player can access one of the mini-games at a time, which can be played in any order. Direction on how to play is provided before each one begins. In all mini-games, points are awarded for providing correct responses and lives are deducted for providing wrong responses. Feedback is given when the player provides a wrong answer. Reward mechanisms, timers and hints are also incorporated in the gameplay. There is no set time for completing each mini-game. Gameplay is open-ended and can keep going until the player loses all available lives.</p>
Environment	<p>The game is made up of an introductory screen where the player can select a mini-game to play, three individual game screens for each one of the mini-games and a statistics interface, where progress can be monitored. Layout design between mini-game screens remains consistent. Placements of key UI elements remain fixed, while interaction elements can be selected via tapping. Graphics are 2D and a minimalistic, clean design style has been adopted throughout.</p>

Player Interaction	The game is single-player and therefore one player can interact with the system at a given time. The system is designed to adapt game challenge to player skill, while data on performance are collected and updated over time, to allow monitoring of performance.
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Table 6-6: *Lexis* design overview

The above table overviews the design of *Lexis*. More details on the game architecture will be provided in the following chapter, which will begin by discussing the development process as well as the expert evaluation that took place before the implementation of the final version of the game. Then, the application of the design guidelines developed previously in Chapter 5 (Developing Design Guidelines for mGBL) to the design of *Lexis* will be overviewed, and suggestions for future developments will be provided.

Chapter 7

Developing Mobile Game-Based Learning

This chapter continues on from the previous one on design, and describes the development process of the game prototype *Lexis*. The first section of the chapter looks into the architecture of the game and provides an overview of the interface design considerations for the initial version of *Lexis*. The following section then moves on to describe the expert review that took place before the second phase of development and discusses design and usability issues that emerged from the review, as well as modifications made for the final version. Then, the design guidelines developed in Chapter 5 (Developing Design Guidelines for mGBL) are revisited and discussed to the extent of their applicability to the design of the game prototype. Finally, the last section of the chapter looks into future developments.

7.1 Developing *Lexis*

This section begins by looking at the initial interface and functionality of *Lexis* and discusses the methodology employed for the game development. It then moves on to describe the play testing evaluation of the initial version, which was conducted in two stages in the form of an expert review. Then the final interface of the game is presented along with the fixes that took place, informed by the outcomes of the review. In the last section of this chapter, areas of future development are highlighted.

7.1.1 Initial Game Version

The initial interface and functionality of the game *Lexis* is here presented as informed by the design requirements previously discussed in both the game

specifications provided in Chapter 6 (Designing Mobile Game-Based Learning) as well as the design guidelines described earlier in this chapter.

Before focusing on interface design however, it was important to first look into further issues relevant to the development of the prototype. In the discussion regarding technology in the previous chapter (see section 6.3.4 Technology) the choice of the development tool was justified, while it was also briefly mentioned that game graphics were to be designed in 2D, due to suitability for the mobile platform but also for the selected game genre style. Furthermore, the quality of the graphics had to be high enough to allow for an attractive, non-distracting and sleek interface. For the requirements of a vocabulary learning game, which was to be text-heavy, the final graphic type for the interface was a combination of 2D and text-based. The style of design was kept minimal, clean and modern, to be appealing to a wide and diverse adult audience and to not draw focus away from the vocabulary. 2D user interface elements and assets were therefore created in the illustration package, Adobe Illustrator and optimised in the image manipulation package, Adobe Photoshop before being imported into the game engine. Additionally, game navigation and interaction was based on single tapping. Touch-based interaction was felt to be appropriate for purpose and context, while it helped keep the interface simple and accessible.

Basic functional requirements for *Lexis* included navigation and status information. The player had to be able to navigate between game screens, and this navigation had to be simple and intuitive. It was important to provide players the ability to access each mini-game, return to the main menu, select another mini-game and exit gameplay at anytime. With regards to status updates the player would have to be able to see all the information about the current mini-game including lives available, current score, time remaining and 'help', as well as any additional information like hints, bonuses and warnings. The game architecture, which is presented below, indicates the main screens of the game and the navigation paths between them.

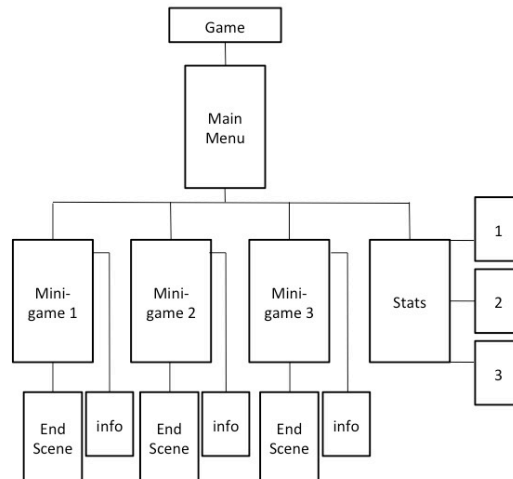


Figure 7-1: The game architecture of *Lexis*

For the initial version of the game prototype all basic functionality was implemented, including navigation and gameplay. It was therefore a fully playable version, missing however supporting functionality such as instructions and help, extra mechanics like bonus points, high scores and star systems and some visual elements. Adaptability of difficulty to player skill, was also build in the initial version of the game, though additional adaptive elements like dynamic customisation of game pace to player performance, were added for the final version. Finally the statistics functionality, which provided information on player performance, was not implemented for the initial prototype. The aim was to originally develop fully playable but simplified versions of all three mini-games and test them, before moving on to developing the final version of the game. The initial game interface can be seen below. It consists of the main game screen and each mini-game's individual interface.

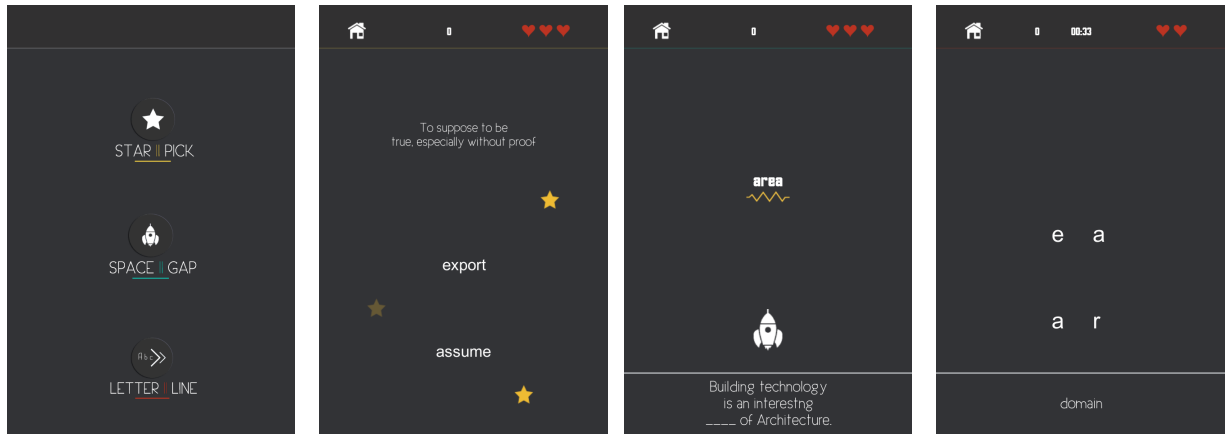


Figure 7-2: Overview of the initial interface of *Lexis*

Via the main game screen, or main menu, the player could choose any of the mini-games to play by tapping once on any of the three icons. Every one of these icons featured the mini-game's name (though names were changed for the final version of the game). All game navigation was achieved via single tapping on any of the hotspots, which detected user input and performed a function.

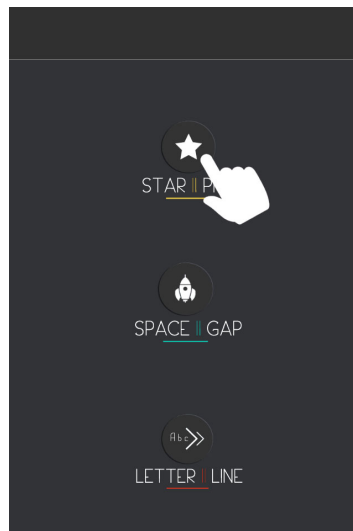


Figure 7-3: *Lexis* main game screen (main menu)

The initial game interface for the first mini-game can be seen below along with the original game wireframe. The interface of the mini-game matched the wireframe in all aspects but the timer, since instead of using the classic count down clock, a fading stars mechanic was adopted instead.

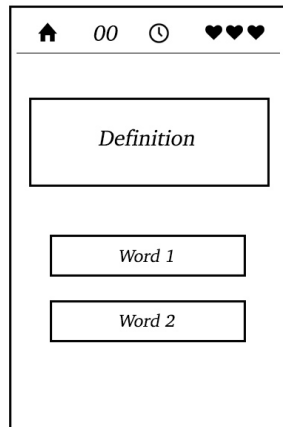


Figure 7-4: Mini-game 1 wireframe

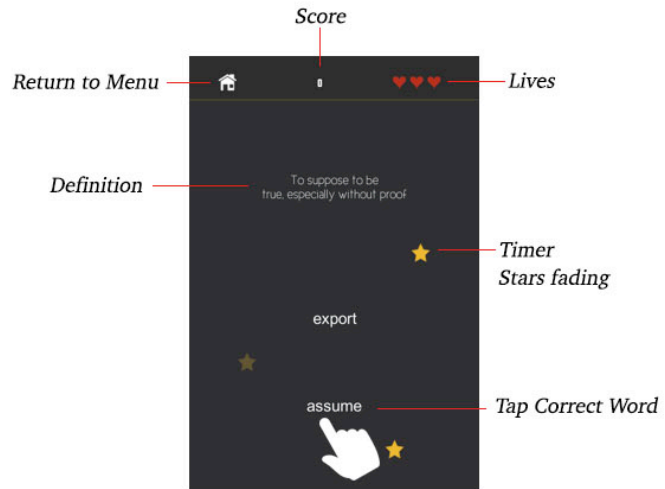


Figure 7-5: Mini-game 1 interface

Mini-Game 1	‘Star Pick’ (name was changed for the final version).
Gameplay	A definition appears on the top part of the screen along with two individual words on the bottom. The player has to tap the word, which is best described by the definition. Feedback is then provided and a new set is loaded. Gameplay goes on until all lives have been lost.
Score	For every correct answer, one point is awarded. Score is not deducted for incorrect answers.
Lives	For every incorrect answer, one life is lost. Once all three lives have been lost, the game ends. For every five correct answers in a row, the player is awarded one life back.
Timer	The total time to select the right word is 15sec. Time is represented by three stars fading one by one, each for five seconds. If when all stars have faded an answer has not been provided, a life is lost. Time is renewed for every new set.
Adaptability	The game adapts the difficulty of the challenge to the skill of the player, featuring sets from either an easier or a more difficult word pools. Furthermore, if an answer is provided in error the same set will be repeated after two sets, to allow learning via repetition.

Table 7-5: Overview of initial version of mini-game 1

The initial game interface as well as the wireframe for the second mini-game can be seen below. The interface matches the wireframe in all aspects but the timer since instead of using a counter the game pace was controlled via adaptability. The better the performance of the player got the faster the words fell. The pace adaptability functionality however was not implemented for the first version of the game but was added later for the final version.

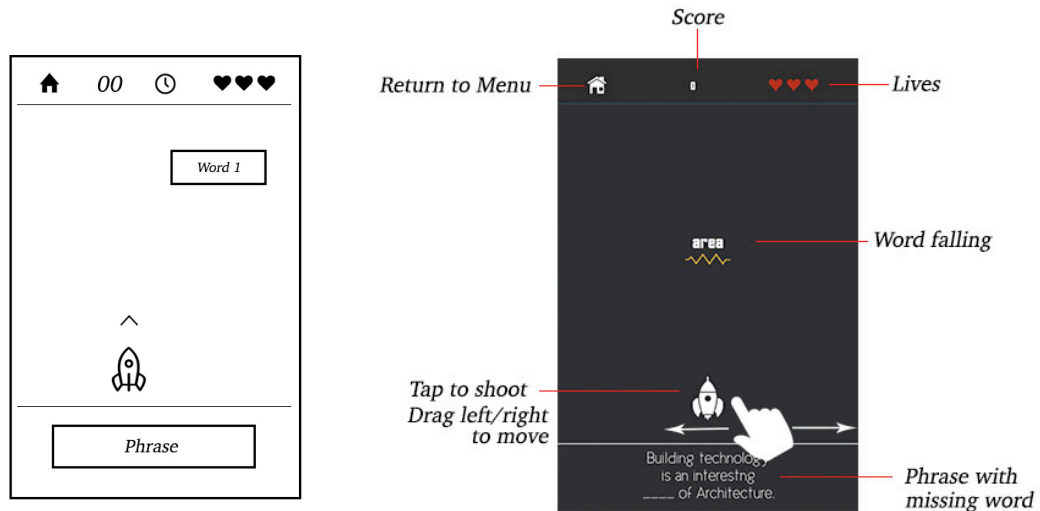


Figure 7-6: Mini-game 2 wireframe

Figure 7-7: Mini-game 2 interface

Mini-Game 2	'Space Gap' (name was changed for the final version).
Gameplay	A phrase with a word missing appears at the bottom of the screen. Soon after, words start falling one by one from the top of the screen downwards. The player has to decide whether each falling word fills the gap correctly. If it does he should let it pass, if not he should shoot it. The player controls a spaceship moving horizontally across the screen, which can be used to shoot the word. Once the player either shoots the word or lets it pass, feedback is provided and a new set is loaded. Gameplay goes on until all lives have been lost.
Score	For every wrong word destroyed, one point is awarded. Five points are awarded for every correct word that reaches the floor.
Lives	One life is lost either when the wrong word reaches the floor or the correct one is destroyed. Once all three lives are lost, the game ends. For every five correct answers in a row, the player is awarded one life back.
Timer	There is a set amount of time (from the moment the word is spawned till it reaches the floor), during which the player has to make a choice to either shoot or let the word pass.

Adaptability	The game adapts the difficulty of the challenge to the skill of the player featuring sets from either an easier words or a more difficult words pool, according to performance.
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Table 7-6: Overview of initial version of mini-game 2

The initial game interface for the third mini-game can be seen below along with the original game wireframe.

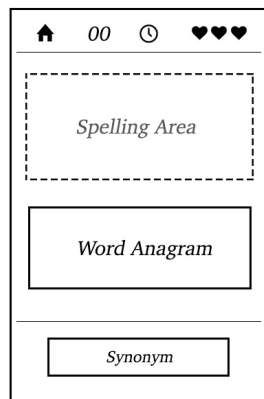


Figure 7-8: Mini-game 3 wireframe

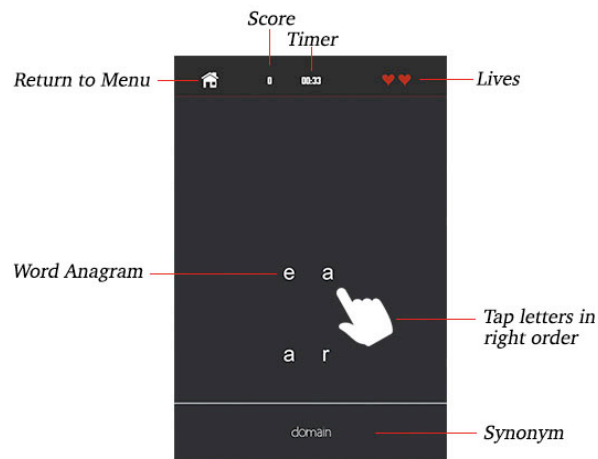


Figure 7-9: Mini-game 3 interface

Mini-Game 3	'Letter Spell' (name was changed for the final version).
Gameplay	The letters making up a word appear in random order on the middle of the screen. At the same time, a synonym of the word appears on the bottom of the screen, as a hint to help the player identify the word. Once the word has been identified then the player has to tap each letter making up the word to spell it. While tapping each letter, the word gradually appears on the top of the screen. Feedback is provided and a new set is loaded. Gameplay goes on until all lives have been lost.
Score	For every correctly spelled word, one point is awarded. Score is not deducted for incorrect answers.
Lives	For every incorrect answer one life is lost. Once all three lives have been lost, the game ends. For every five correct answers in a row, the player is awarded one life back.
Timer	The total time to identify and type the word is 40sec. Time is represented by a counting down timer. If when time is up an answer has not been provided or is incomplete, a life is lost. Time is renewed for every new set.

Adaptability	The game adapts the difficulty of the challenge to the skill of the player featuring sets from either an easier or a more difficult words pool, according to performance.
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Table 7-7: Overview of initial version of mini-game 3

Navigation and status information remain consistent between all three mini-games. At the end of gameplay for each mini-game, when all lives have been lost, an overlay screen appears (as seen in the following figure). Tapping on one of the icons on the screen, the player can either play the game again or return to the main menu to select another game to play.



Image 7-10: End of gameplay overlay screen

At this point it is important to clarify a design decision in relation to the guidelines presented earlier in the thesis (see section 5.3 Guidelines for Designing Mobile Learning Games). Looking at the last set of proposed guidelines for mobile game-based learning referring to effective games design, one of the criteria for G5 is: ‘Rewarding rather than punishing mechanics’. This criterion could arguably be conflicting with the design of the above mini-games in that they all feature a score as well as lives. It is therefore important to clarify that the criterion is referring to the maximisation of reward and the minimisation of the importance of punishment during gameplay, however the complete elimination of what could be considered as a punishing mechanic may not be possible in all designs. Regarding *Lexis*, punishment has been minimised since score is only awarded for correct answers and not deducted

when a wrong answer is provided. On the contrary, when players provide a wrong answer feedback is given to allow them to learn it. Lives are lost when a wrong answer is provided since this is a necessary mechanic to meet the end of gameplay condition, otherwise since all mini-games are open ended, gameplay would continue on forever and the end state would never be reached. No other type of punishment is however featured in the game such as loss of resources or power, downgrading or any other type of discouraging event. On the same time, to ease the mechanic of loosing the life, a bonus condition has been implemented in the game where a life is awarded back to the player when five correct answers are given in a row. It is therefore felt that punishment in *Lexis* is minimised and that balance is achieved in the design with regards to the above criterion, while on the same time addressing the functional requirements of the system.

Having developed the initial game version, a step that was considered crucial for the development process was the play testing phase (Fullerton et al., 2004), which is usually conducted on a game prototype before the final version is released. Play testing can help maximise quality by refining aspects of the game and is often carried out with potential users and/or subject experts. Since play testing is a common practice in the development of commercial games, it was decided that it would be equally useful for the development of a learning game as well. Play testing was therefore conducted on the initial version of *Lexis*, in the form of an expert review with subject experts and with potential users. The aim was to identify game design and usability issues. Furthermore, although examining the learning effectiveness of the game was to be the aim of the final user evaluation, an additional play testing event was carried out with learning experts, to gain some initial insight. The results of the play testing were utilised to shape the design approach for the final iteration of development and to inform modifications and fixes. The next section of this chapter therefore looks into the expert review process and how problems identified were addressed for the development of the final version of *Lexis*.

7.1.2 Expert Review and Fixes

The development methodology used for *Lexis* was an iterative one, involving two development cycles. On completion of the first iteration, play testing took place to examine how the prototype met the design requirements and to extract findings to inform the final iteration of the game development. This section thus describes the details of the play testing that was conducted after the development of the initial version of *Lexis*. Play testing took place in two stages, while the outcomes are discussed below.

The first stage was an expert review with subject experts and potential users, which aimed at identifying game design and usability issues. Focus was on the evaluation of gameplay, functionality and interface design in order to examine the overall user experience. The method employed was the think-aloud protocol, which is a commonly used method in usability testing to obtain insight into the user experience (Nielsen, 1993). It consists of the user verbalising their thoughts while performing tasks, talking about their actions, expectations and perceptions about the interface and the functionality of the system. An administrator, or in this case the researcher, often sits beside the user observing and prompting them to keep verbalising their thoughts. Though the think-aloud protocol is often used for usability evaluations, it can also be effective in design and gameplay evaluations, when the reviewers' expertise is relevant. Here eight expert reviewers were recruited, each specialising in a key area suitable for the evaluation of a mobile learning game. The expertise of each reviewer can be seen in the following table:

Reviewer	Expertise
1	Educational Software Design
2	Game-based Learning
3	Educational Applications and Content Development
4	Serious Games Usability
5	UX for iOS Products
6	Mobile UX/Usability and UI Design
7	Software Development and Systems Architecture
8	Linguistics

Table 7-11: Areas of expertise of the reviewers of *Lexis*

Expert reviewers were recruited from the researcher's colleagues and professional connections. In addition, four testers were recruited from a potential users' pool to play test the game, which allowed for a more user-centred evaluation approach. These four testers were adults between 28 and 34 years of age, while two of them were students and two were professionals. They were all non-native speakers of English but with an advanced command of the language and were also experienced with the system, being owners of an iOS device for a period greater than three months. Before the beginning of the session, reviewers were introduced to the research and its aims and were asked to complete a consent form (see Appendix B.1 for expert reviewer consent form and Appendix B.2 for game tester consent form).

The second stage was a presentation of the prototype followed by a feedback session with learning experts. Learning experts were the members of the Learning and Adaptive Environments (LAER) Research Lab of the University of Edinburgh. Lab members consist of academics, researchers and postgraduate students engaging in work on the creation, design and evaluation of technologies for learning and development. The aim of this feedback session was to get insight on the learning potential of the game as well as the suitability of the learning content to inform the design of the final version. As issues were encountered in both stages of the review, they were documented and then grouped and prioritised in the form of fixes to be implemented for the next stage of development. Following, the fixes made as a result of both stages of the expert review, are presented and discussed.

Fix 1 – Game objective description for each mini-game

Though most reviewers understood the objective of each mini-game after a short time of interacting with the system, the majority noted that it would be useful to add some sort of description about the objective of each mini-game before gameplay begun. This would help players understand what was expected of them in the game and allow a short period of time for preparing themselves before jumping strait into

gameplay mode. To that direction, description overlays were added as landing screens for all three mini-games, prior to gameplay starting. Overlays appeared and remained on the screen for a few seconds so they could be read and informed the player of the main objective of the game. Everytime a mini-game was started the corresponding overlay was activated.

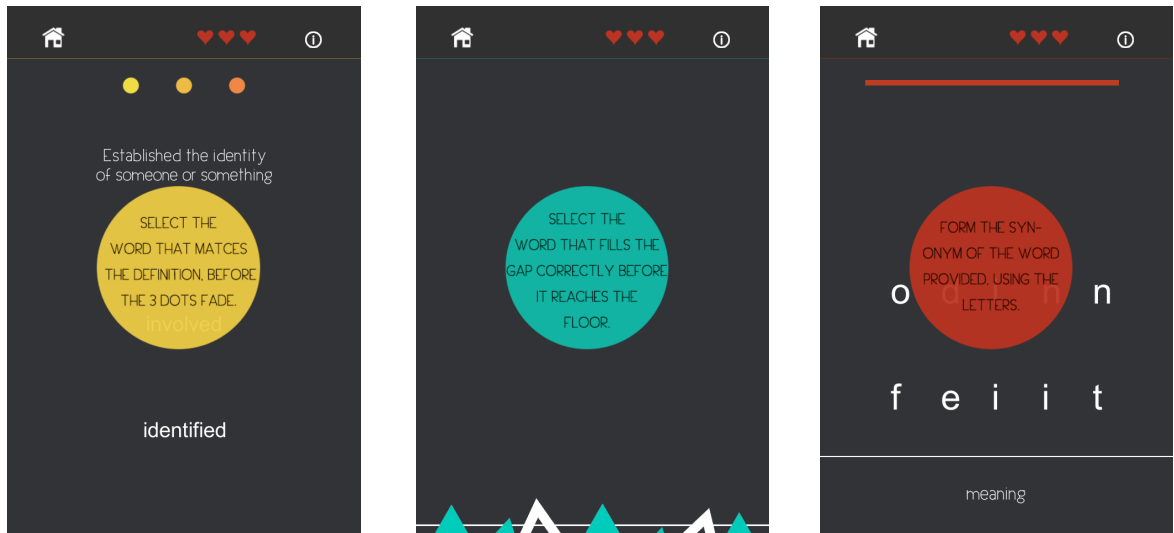


Figure 7-11: Description overlays for each of the mini-games

Fix 2 – Help functionality

An additional suggestion that came up during the review was the need for help functionality. This would be useful in case the objective of the game was not clear even after reading the overlay, or in case more information about the game were required. A tappable information icon was therefore added on the top right corner of the interface to assist players who needed more information. The position of the icon in the user interface remained consistent amongst all three mini-games.

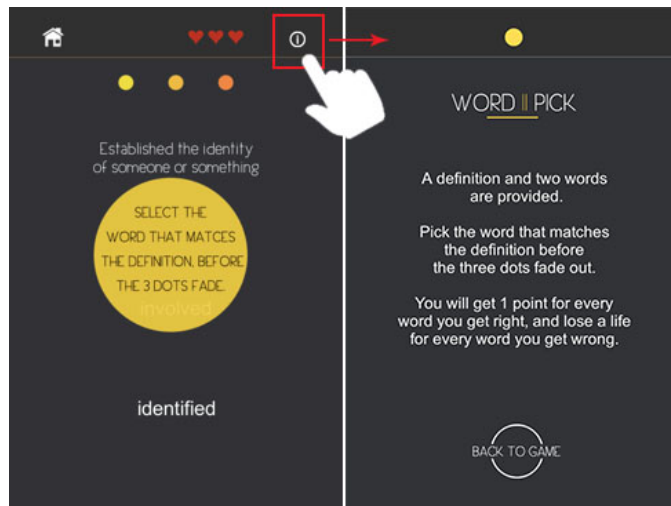


Figure 7-12: Information icon and help screen for mini-game 1

Fix 3 – Main menu label

A small but important fix suggested, was the addition of a label on the main menu screen to inform the player that any mini-game could be played. This way it would become clear that all games were accessible and that they could be played in any order even from the first interaction with the system. The label which was a static UI element, was added on the top of the main menu screen.

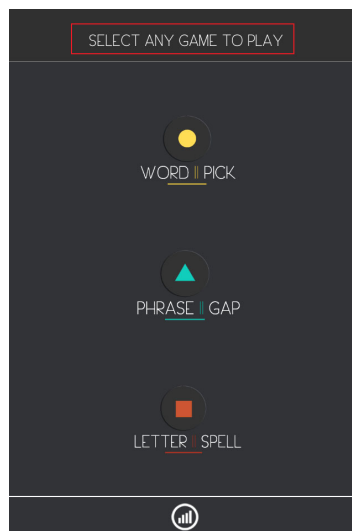


Figure 7-13: Main menu label

Fix 4 – Redesign of the end of gameplay screen

During the second iteration, the end of gameplay screen which is common between all three mini-games, was redesigned. First, it was decided to change the position of the tappable buttons for replaying and for navigating to the main menu. Additionally, the score achieved during gameplay was now displayed on the screen. Feedback from the review suggested that it would be useful to provide not only the score but also an indication of the highest score ever achieved to promote motivation. A high score label was therefore added to the interface featuring the highest score awarded for a given mini-game. Finally, a three star mechanic was incorporated to provide a visual cue on player performance. This was also suggested by some of the reviewers who were more familiar with mobile gaming conventions and indicated that players of mobile games often expected a three star reward system. According to performance, none, one, two or three stars were awarded to the player at the end of the game. Furthermore, there were four labels that accompanied the stars: ‘try again’ when no stars were awarded, ‘good’ for one star awarded, ‘great’ for two stars and ‘excellent’ for three stars. The differences on the interface between the end of gameplay screen for the first and second iteration of the game can be seen below.

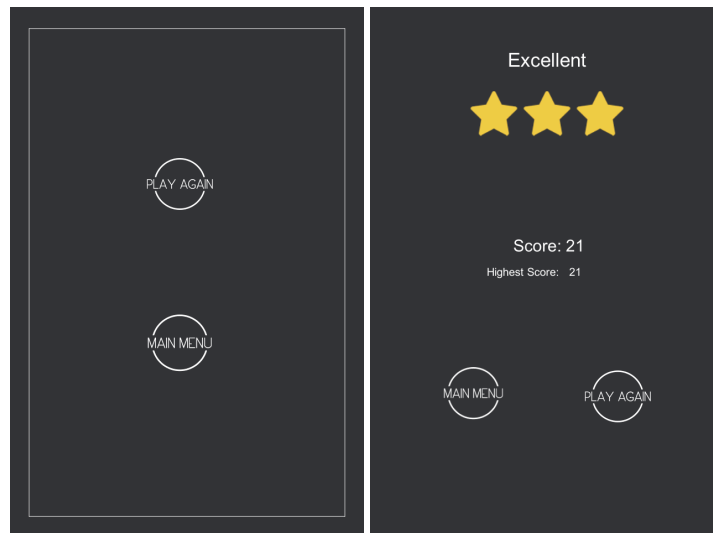


Figure 7-14: The end of gameplay screen for the first and final version of *Lexis*

Fix 5 – Visual Feedback

In the initial version of *Lexis* feedback was provided in various ways, including the score and lives, however it was important to implement visual feedback for correct and incorrect answers as well. Reviewers pointed out that this would help players realise more clearly whether their response was correct or not, since sometimes they might not immediately notice the score changing or the life being lost. A visual system of a ‘tick’ and an ‘x’ icon was therefore utilised for correct and incorrect answers. Additionally for every incorrect answer the correct word was provided to allow players to make associations, and to assist memory.

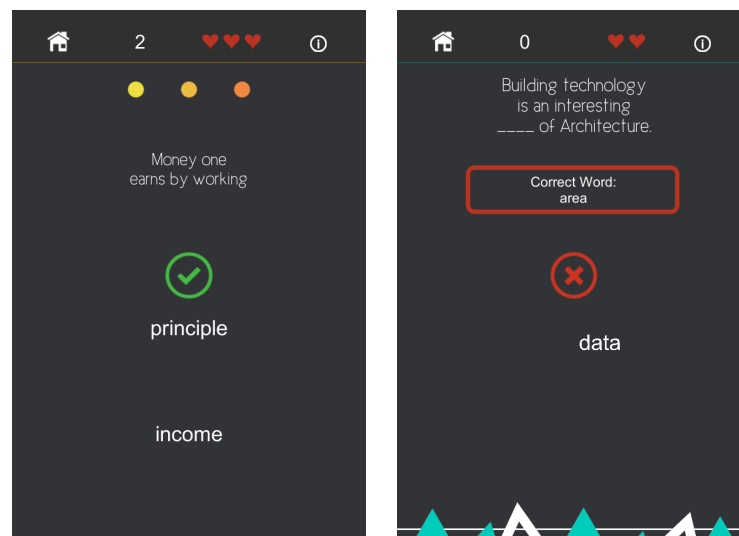


Figure 7-15: Visual feedback for correct and incorrect answers

Fix 6 – Flag time is running out

Another issue that came up during the review was the fact that often, reviewers did not seem to notice time running out, which caused a feeling of uncertainty as to why a life was lost and the set was changed without an obvious reason. It was therefore felt important to flag time was running out in a more clear, visual way. An overlay label was implemented and appeared when five seconds were remaining, in order to inform the player that time was about to run out.

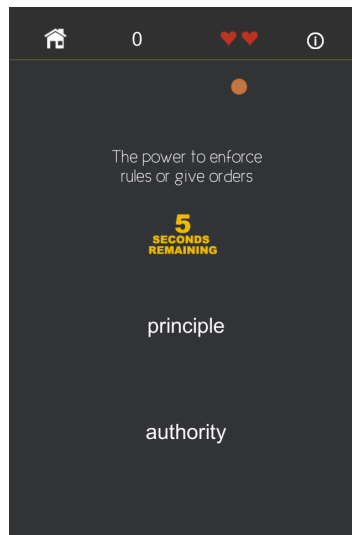


Figure 7-16: '5 seconds remaining' overlay label

Fix 7 – Mini-game 1: Change timer appearance

For the first mini-game, a visual representation of time was used instead of a classic count down clock. Feedback from the review supported the idea of utilising a visual time measurement mechanic. One of the reviewers even said that it took pressure off in comparison to a ticking clock and that it added playfulness to the experience. The implementation of the visual representation of time via the fading stars scattered around the screen however, proved to be distracting during gameplay. Furthermore, since the stars were randomly positioned in the main area of interaction in-between the words and the definition, some reviewers initially thought they were part of gameplay and that they were tappable. Finally, confusion was caused by the fact that reviewers familiar with mobile gaming conventions made mental associations to the three star reward mechanic as a measure of performance as opposed to time. It was therefore decided to retain the original idea but change the stars to fading dots and to reposition them lining up on the top of the screen, instead of randomly positioning them in-between the text. The idea of the dots was informed by the mini-game's theme which was a yellow circle, as it appeared on the main menu screen. To enhance the visual identity of the game therefore stars were replaced by fading dots.

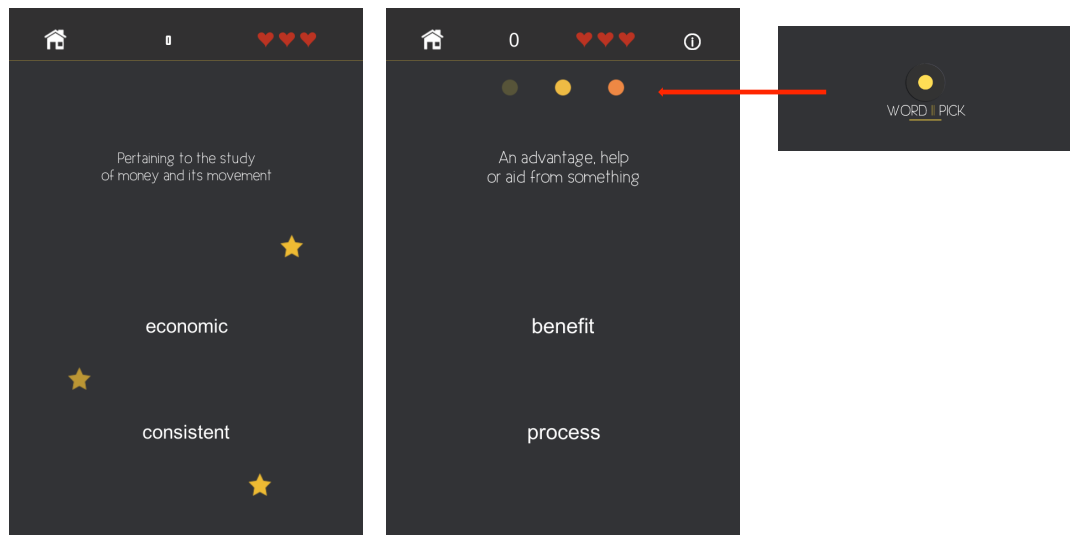


Figure 7-17: Visual timer changed from fading stars to fading dots

Fix 8 – Mini-game 2: Gameplay redesign

Through play testing and review various issues arose with mini-game two. Overall the game was less functional and intuitive in comparison to the other two mini-games. Reviewers noted that gameplay created cognitive overload since the player had to read the sentence and the falling word, decide whether to shoot the word or not and then move the ship and fire; therefore too many actions were required at one time. At the same time the sentence positioned at the bottom of the interface was difficult to read, since the player's hand was often over the word while dragging the ship. Learning experts also pointed out that words started falling too fast when gameplay began and thus the player had insufficient time to read the sentence. Furthermore they advised that the game reinforced "reverse psychology", since it asked players to shoot the wrong words and let the correct one pass. This way, players interacted with the wrong words instead of the right one, which essentially led them to remember the wrong words. Mechanics had to therefore be reversed to foster interaction with the right word.

Certain amount of redesign had to take place to make the game more functional and more intuitive. It was therefore decided to simplify gameplay by removing the spaceship altogether. In the final version of the game the sentence was positioned on

the top of the interface so as to be clearly visible. When gameplay begun, words started falling one by one on a low speed which allowed time to read the sentence. The player had to then decide whether the falling word was suitable to fill in the gap correctly and if so tap it, or otherwise let it pass and fall on the floor. As game progressed, the speed of the falling words adapted to the skill of the player so the better the performance the faster the words fell. For every correctly selected word one point was awarded and for every wrongly selected word, or if the correct word was not selected and was left to hit the floor, a life was lost and a new set was loaded. The differences between the game's initial and final interface can be seen in the following figure.

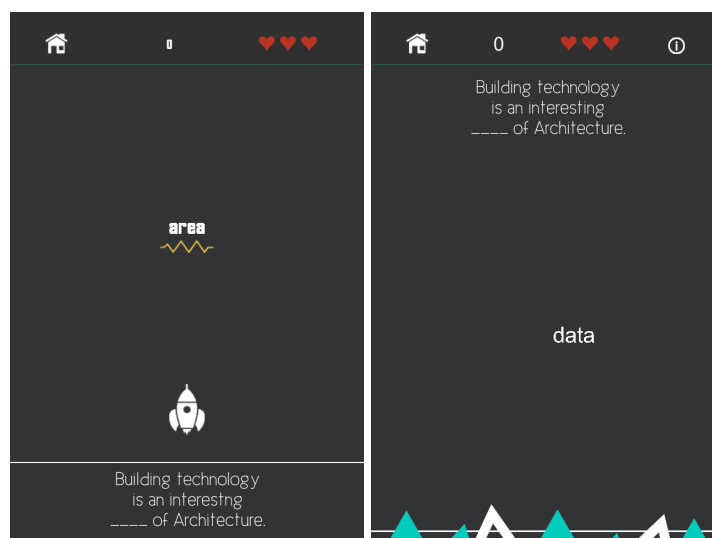


Figure 7-18: Redesign of game interface

Fix 9 – Mini-game 3: Implementation of a visual timer

The first fix that was implemented for mini-game 3 was the replacement of the countdown clock which was originally used, with a visual timer. The visual timer was a straight line, symmetrically shrinking from both sides as time passed. This change was informed by the positive feedback on the use of a graphical time measurement mechanic, which resulted from the expert review. Additionally, since a visual representation of time was also implemented for mini-game one, it was felt consistent to utilise a similar technique for mini-game three as well, by removing the

text-based countdown clock which was based on numbers rather than graphics. This decision was further supported by feedback from the expert reviewers, according to whom visual timers put pressure off gameplay in comparison to countdown clocks. Similarly as with mini-game one, the design of the timer for mini-game three was informed by the theme of the mini-game which was the red square, as it appeared on the main menu screen. Thus the visual representation of time took the form of a shrinking line, which gradually resulted to a red square as time passed.

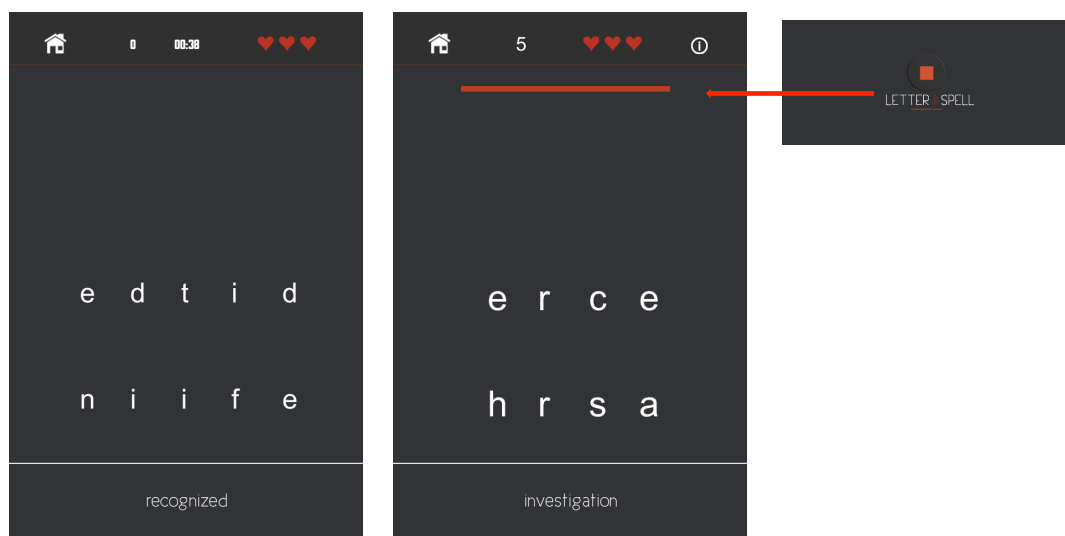


Figure 7-19: Change from text-based to visual timer

Fix 10 – Mini-game 3: Hint functionality

As discussed on the previous chapter, the three mini-games were designed to address specific learning objectives for vocabulary building. This collection of increasing difficulty mini-games, featuring different puzzles with the same content was thought to assist scaffolding. Scaffolding was also supported by the puzzle design and the adaptability of the system. However a suggestion that came up from the learning experts was to add a hint mechanic on the third mini-game. The first letter of the word to be spelled was therefore provided as a hint, after 15 sec of non-interactivity with the system.

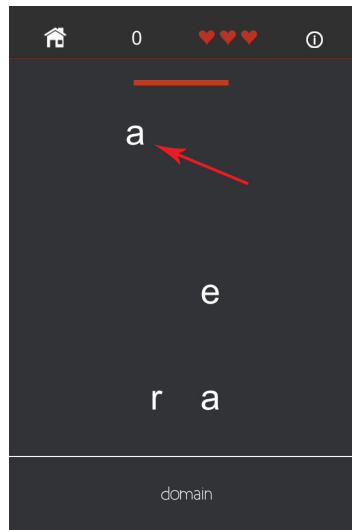


Figure 7-20: The first letter of the word provided as a hint

Fix 11 – Naming and text adjustments

One key observation made by many of the reviewers was the fact that text could be slightly bigger to allow for more comfortable reading. To that end, fonts were made bigger for all mini-games. Furthermore, the original names of the three mini-games were changed to reflect the changes of the design. Mini-game one, originally named: ‘Star Pick’ was renamed to ‘Word Pick’ since stars were removed from the interface. The name for mini-game two was changed from ‘Space Gap’ to ‘Phrase Gap’ due to the overall redesign not featuring the spaceship anymore. Finally the third mini-game, originally named: ‘Letter Line’ was renamed to ‘Letter Spell’ since the name felt more appropriate to describe the game objective. In addition, icons for all games were simplified and changed to basic geometrical shapes each painted with the characteristic colour of the mini-game’s interface. Differences between the initial and final main menu screen, featuring the new game names and icons can be seen below.

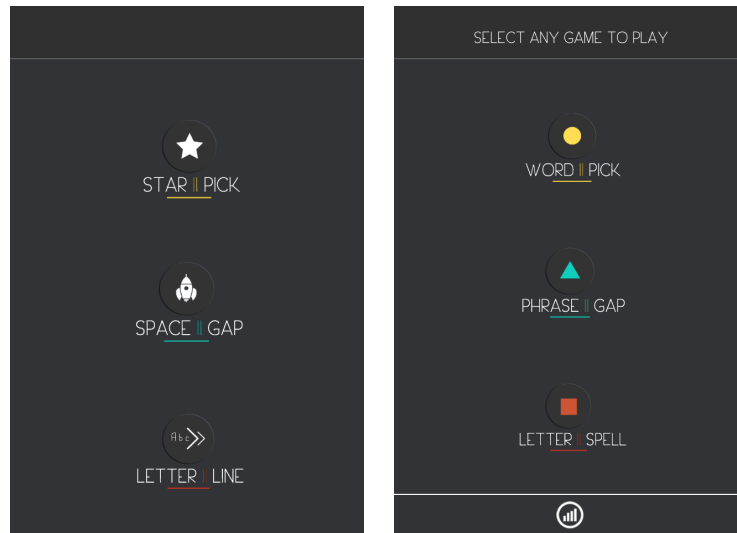


Figure 7-21: Game names and icons for first and second version

Fix 12 – Improving system response time

One technical issue that was pointed out during play testing was the occasional low response time of the system, especially when new sets were loaded. This issue was identified in the way the game had been originally developed, according to which word sets were stored in a JSON file and loaded to the UnityScript via an external library that parsed the JSON object and transformed it into a data structure. To save resources and avoid unnecessary complication however it was decided to use a simple text file, inside which word sets were saved as dash-separated strings. This data structure could then be used in gameplay, being parsed programmatically via UnityScript without the need for an external library. This solution improved the response time of the system and assisted overall resources saving. Furthermore it allowed customisation of content, since anyone with access to the text files could replace existing word sets and change the vocabulary used in gameplay. It therefore allowed future repurposing of the system for other types of vocabulary as well.

Fix 13 – Game pace adaptive to player performance

Though adaptability was implemented for the initial version of the game, it primarily focused on adapting the difficulty of the challenge to the skill of the player. For the final version however, adapting game pace to player performance was also implemented. Feedback from the review indicated that this feature would be useful to signify state changes to the player as gameplay progressed and to help retain motivation. Adaptability of game pace was therefore implemented for all three mini-games, with mini-game one and three adjusting available time to player performance and mini-game two adjusting the speed of the falling words.

Fix 14 – Statistics

Statistics were implemented for the final version of the game. The aim of adding this functionality was to allow players to monitor their learning over time. Statistics for each of the three mini-games indicated the top ten mastered words and the top ten words that still need to be learned, according to the performance of the player in the game. The top words that were correctly used the most times and the top words that were wrongly used the most times, were featured in the statistics. This way the player could monitor the vocabulary he had a good command of and that which needed more exercising on. Statistics changed according to correct and incorrect answers given, and were dynamically modified as time passed. They could be accessed via the icon on the bottom of the main game menu, as seen in the following figure.

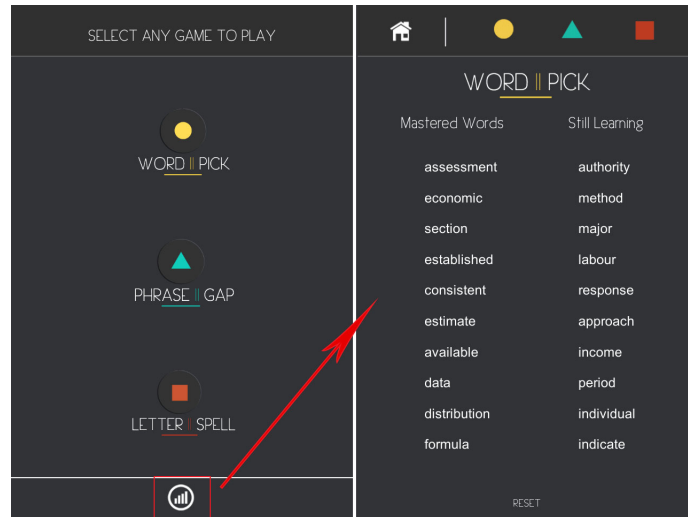


Figure 7-22: Statistics icon and interface

This section has described the expert review of *Lexis* and the changes made to the initially developed prototype as informed by the issues that arose during play testing. There was however one further suggestion proposed by the learning experts during the second stage of the review, which was not implemented since it was not considered fit for purpose. The suggestion was to use an alternative representations approach and include images as visual stimulation for players. It was felt that associations of meaning with visual representations of words would help the player's memory. Though this is good practice for language learning, the type of vocabulary used here was not considered appropriate for visual representation. Meanings of academic words were felt to be relatively abstract to be represented by a single image or illustration, which the player could easily and explicitly identify as representing the meaning of a given word.

The final game interface, after fixes had taken place can be seen below. It consists of the main game screen as well as each mini-game's individual interface.

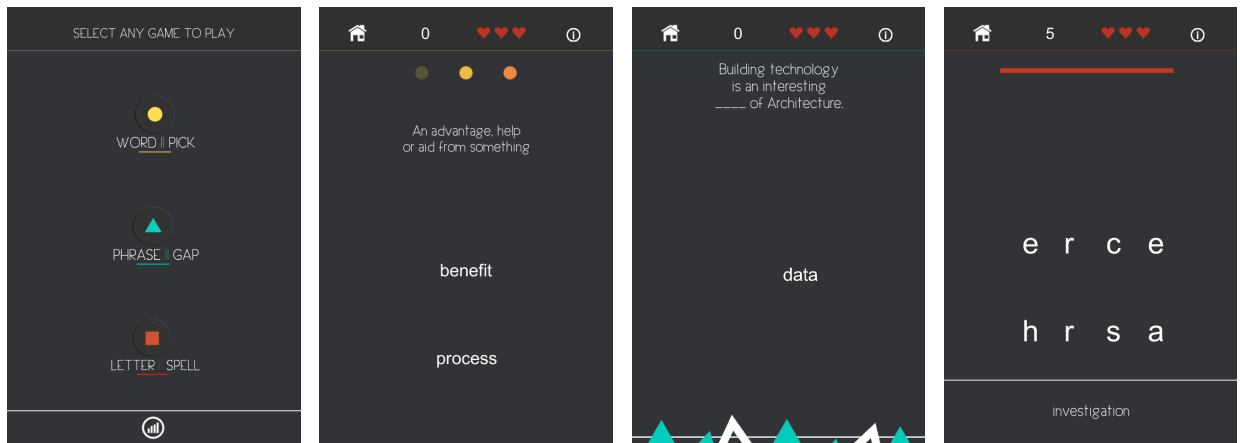


Figure 7-23: Overview of the final interface of *Lexis*

In the following section, the design of the final version of *Lexis* is discussed in relation to the design guidelines for mobile game-based learning proposed in Chapter 5 (5.3 Guidelines for Designing Mobile Learning Games). The aim of the discussion is to compare the design of the game against the requirements set by the guidelines, and to demonstrate how these were implemented in *Lexis*.

7.2 Applying Design Guidelines to *Lexis*

The design of *Lexis* is here considered against the four sets of guidelines proposed in the last section of Chapter 5 (5.3 Guidelines for Designing Mobile Learning Games). These four sets have to do with learning design, engagement, usability and game design. The extent of applicability of each guideline to the design of the prototype is discussed below.

The first set is that of learning design, featuring six guidelines. These are the ability of the game to promote self-direction, support independent learning, provide a personalised experience, support active learning, feature replayable micro-content and be appropriate for the context. The design guidelines along with their descriptive criteria are initially presented on the left column of the tables below, followed by the

ways in which they have been addressed in the design of *Lexis*, presented on the right column.

L1	Promote self-direction	
<ul style="list-style-type: none"> - Choice over the learning task. - System should provide constant support. - Control over the pace of learning. - Allow customisation of content according to personal needs. 		<ul style="list-style-type: none"> - Three mini-games to choose from each targeted to a specific vocabulary building skill. - System provides feedback on performed actions, supporting players throughout. - Pace in all mini-games adapts to player performance. - Customisation of learning content is not supported in the current version of <i>Lexis</i> (proposed future development).
L2	Support independent learning	
<ul style="list-style-type: none"> - Control over where and when learning takes place. - Flexible and accessible content, across contexts. - Design for learner's personal device. - Learning independent from others. 		<ul style="list-style-type: none"> - Learning is flexible since the player can choose when and where to play the game and play sessions are short. - Content is accessible across contexts and is independent from external requirements such as wireless connection. - <i>Lexis</i> is a native application, thus downloadable and available on the learner's personal device. - The game is not depended on others (e.g. peers or tutors).
L3	Provide a personalised experience	
<ul style="list-style-type: none"> - Support a range of expertise. - Challenge adjustable to learner's competence. - System adaptability to the learner's progressively evolving skills. - Ability to monitor progress. 		<ul style="list-style-type: none"> - Adaptability of content difficulty makes the game relevant to various levels of prior knowledge. - Challenge and pace are adjustable to players' skill, thus accounting for different levels of performance. - System dynamically adapts to players' evolving skill; as the player becomes better over time, gameplay becomes more challenging and faster-paced. - Progress over time is monitored via statistics and high score. Due to device ownership, data are relevant to the individual player.

L4	Support active learning	
<ul style="list-style-type: none"> - Encourage problem solving. - Promote task-based learning. - Opportunities to test ideas and get feedback. - Game goals aligned with learning goals. - Practice over memorisation. 		<ul style="list-style-type: none"> - Game activities are word puzzles and are designed based on problem solving. - In-game learning activities have been designed as tasks to be performed (active participation). - Mini-games allow exposure to the meaning and use of vocabulary, in the way of trial and error type exercises. - All mini-games have an explicit game goal aligned with the learning goal (support rather than detract from learning). - Learning activities favour practice over memorisation (e.g. puzzles instead of flashcards).

L5	Create repayable micro-content	
<ul style="list-style-type: none"> - Content in small, manageable units. - Learning should match time available. - Open-ended learning. - Foster repetition till proficiency, via replayability. 		<ul style="list-style-type: none"> - The mini-games architecture helps divide content into smaller and more manageable thematic units. - Mini-games coupled with short play sessions, allow for easier integration into busy everyday schedules. - All mini-games are open-ended enough to be replayable and to allow players to reach break-throughs. - Quick and simple interactions coupled with flexibility of access enhance replayability.

L6	Consider appropriateness	
<ul style="list-style-type: none"> - System unobtrusive and persistent. - Learning data accessible and transferable. - Content appropriate for the subject matter. - Content relevant and with real-world application. 		<ul style="list-style-type: none"> - <i>Lexis</i> is designed for iOS and runs on the iPhone, which is a stable, unobtrusive and persistent system. - Learning data are stored during gameplay and content is accessible. System architecture allows for future implementation of data transfer between iOS devices. - Language vocabulary is learning content appropriate for the subject matter (see Chapter 6). - English vocabulary is considered relevant and with real-world application (words can be used in everyday verbal or written interactions).

The second set of guidelines discussed in relation to their applicability to the design of *Lexis* is that of engagement. Five guidelines are included in the set, which are the ability of the game to provide challenge and feedback, foster interaction, promote stimulation and feature adaptability. The design guidelines along with their descriptive criteria as well as the ways in which they have been addressed in the design of *Lexis* are presented on the tables below.

E1	Game should provide challenge	
	- Challenge appropriate to player skill.	- Challenge remains appropriate via system adaptability and pace adjustment according to performance.
	- Challenge gradually introduced, increasing in difficulty.	- Challenge is gradually introduced via the three mini-games (third mini-game more challenging than first).
	- Foster feeling of winnability.	- Difficulty and pace adjustment featured, along with intuitive controls foster winnability.
	- Facilitate personalisation and/or adaptability.	- Adaptability is integrated in the system. Personalisation is not however and could be implemented in a future version of the game.

E2	Game should provide feedback	
	- Feedback should be meaningful.	- Feedback is provided regarding the objective of each mini-game in an interactive, responsive manner, which supports learning via trial and error.
	- Clearly indicate progress towards a goal.	- Since all mini-games are open-ended an end goal is not set, instead the player can keep playing aiming at becoming better and beating their own high score. Progress towards a larger learning goal can be monitored via statistics.
	- Show player status.	- When a response is given in error, the game signifies what the correct answer was, so it can be learned. Visual feedback is also provided via the lives lost and regained and via a star system at the end of the game.
	- Help functionality should be obvious.	- Help functionality is provided for all mini-games and is clearly visible via the interface.

E3	Game should foster interaction	
<ul style="list-style-type: none"> - High level of interactivity. - Encourage active participation. - Interactivity in sync with pace. 		<ul style="list-style-type: none"> - <i>Lexis</i> was designed to be highly interactive. - Gameplay is based on user input. - Pace is adaptable according to performance, thus the speed of interaction changes in the game.

E4	Game should promote stimulation	
<ul style="list-style-type: none"> - Information processing via sensory curiosity. - Understanding via cognitive curiosity. - Story/Fantasy (where applicable). - Utilise humour (where applicable). 		<ul style="list-style-type: none"> - Sensory stimulation is enhanced via overlay information elements occurring incrementally, such as a bonus label and a '5 seconds left' warning. - Although there is no back-story, stimulation in the form of cognitive curiosity is present via the abstract minimalistic design of the game, which invites players to infer meaning. - Fantasy is not applicable in <i>Lexis</i>. - Humour is not applicable in <i>Lexis</i>.

E5	Game should be adaptable	
<ul style="list-style-type: none"> - Difficulty adaptable to player skill. - Gameplay personally relevant. - Monitor progress and play patterns. - Adjust system to individual player. 		<ul style="list-style-type: none"> - The game dynamically adapts difficulty and pace according to player skill. - Game is designed to be playable on an individually owned device, adapts to player skill and monitors performance. - Progress is monitored via built in learning statistics, updated in real time. - Via the above functionality, the system adjusts itself to the individual player, thus enhancing the feeling of self-confidence and control.

The next set of guidelines discussed in relation to applicability to the design of *Lexis* is that of usability, featuring six guidelines. These are the ability of the game to support multiple contexts, the efficiency of the screen layout, the simplicity and ease of controls, the responsiveness of the game, the clarity of goals and progress and finally the sense of control the player should have when using the system. The following tables present the guidelines and the ways in which each has been addressed in the design of *Lexis*.

U1	Multiple contexts support	
<ul style="list-style-type: none"> - High contrast to enhance visibility. - Font size comfortably readable. - Gameplay should not rely on sound. - Game playable with one hand. 		<ul style="list-style-type: none"> - UI design utilises high contrast foreground and background colours (white over dark grey) to allow visibility in various lighting conditions. - Font sizes are appropriate to be comfortably readable both indoors and outdoors. - The game features no sound. Gameplay does not rely on sound feedback or spoken input. - Interaction in all mini-games is based on single tapping, thus gameplay is possible with one hand.

U2	Screen layout efficient, uncrowded and pleasing	
<ul style="list-style-type: none"> - Screen layout should not feel crowded. - Required information always visible. - Game should run in full-screen mode. - Screen layout consistent between mini-games/levels/devices. - Screen layout dynamically adjustable between orientations. 		<ul style="list-style-type: none"> - Screen layout design is minimalistic and remains uncrowded (use of 'white space' present). - Required information has been kept to a minimum to avoid overcrowding screens and is always visible. - The game runs in full screen mode by default. - Screen layout is consistent between all mini-games. Default UI elements remain on fixed positions. - Free orientation is not supported; the game only runs on a portrait orientation.

U3	Intuitive controls	
<ul style="list-style-type: none"> - Controls intuitive and logical. - Eliminate error-prone conditions. - Navigation clear and consistent. - Short navigation paths. - Easy access to home/main menu. 		<ul style="list-style-type: none"> - Game controls are kept simple, while the interaction method is gesture driven based on single taps. - Controls remain consistent between mini-games to minimise error-prone conditions. - Navigation is intuitive and logical. - All paths are short, one or two levels deep, thus eliminating the need for shortcuts. - There is direct access to the main menu via all the mini-game interfaces.

U4	Game responsive	
<ul style="list-style-type: none"> - Short response time to user input. - Input recognition via feedback. - Feedback provided on appropriate time. - Clear that the game has ended. 		<ul style="list-style-type: none"> - The game is responsive, although there is a know issue with input sensitivity on the third mini-game.
		<ul style="list-style-type: none"> - User input is recognised via feedback in the form of status indicators, timers, scores and lives, updated in real time.
		<ul style="list-style-type: none"> - Feedback is provided on appropriate time, immediately after tapping.
		<ul style="list-style-type: none"> - It is clear that each mini-game has ended, via the use of an end of gameplay overlay screen.

U5	Goals and progress clear	
<ul style="list-style-type: none"> - Short/long term goals clear. - Short-term goals foster motivation towards larger goal. - Choice over predetermined and player-driven goals. - Progress towards goals monitored and/or comparable. 		<ul style="list-style-type: none"> - The overarching long-term goal is clear (achieve best performance, leading to mastering vocabulary).
		<ul style="list-style-type: none"> - Short-term goals (e.g. understand the meaning of a word) lead to long-term goal (mastering vocabulary).
		<ul style="list-style-type: none"> - Player-driven goals are not supported at the present time, but could be implemented in a future version of <i>Lexis</i>.
		<ul style="list-style-type: none"> - Performance monitoring towards the long-term goal is visible via statistics. Progress towards short-term goals is obvious via feedback, score and lives and measurable by the star system and high score.

U6	Player should feel in control	
<ul style="list-style-type: none"> - Obvious how actions affect gameplay. - Quick recovery from errors. - Support trial and error. - Allow customisation. 		<ul style="list-style-type: none"> - Players are able to make decisions, act and see the outcomes in the game in real time via feedback. Instructions for all mini-games are explicit, visible at the beginning of each game and also accessible via the help button.
		<ul style="list-style-type: none"> - Progress is automatically saved, thus enabling easy exit and re-join. Auto saving also supports quick recovery from errors (e.g. accidentally terminating the application).
		<ul style="list-style-type: none"> - Gameplay is based around trial and error, since the player gets feedback on decisions made, so ideas can be tested.
		<ul style="list-style-type: none"> - Customisation is not supported and could be implemented in future versions of the game (see section 7.2.3 Future Development).

The final set of guidelines discussed in relation to their applicability to the design of *Lexis* is that of mobile game design. Six guidelines are included in the set, which are mobile appropriateness, short play-sessions, pick up and play, flexibility, rewards and visual design appropriateness. The following tables present the guidelines (left column) and the ways in which each has been addressed in the design of *Lexis* (right column).

G1	Design for mobile	
	- UI assets optimised for mobile.	- All UI assets are designed targeting the iOS interface and optimised for Unity mobile.
	- Visual quality, for all screen resolutions supported.	- Values of two (e.g. 32x32) and the .png file format are used for 2D assets, which were tested for quality and clarity on both Unity Remote and the testing device (iPhone).
	- Touch-based controls over virtual control buttons.	- Game interactions are based on touch-screen input and virtual control buttons are avoided.
	- Design for speed and recovery.	- Auto save functionality is implemented to allow for quick recovery. Also, assets are optimised for mobile to assist speed.

G2	Shorter play sessions	
	- Design gameplay around short play sessions.	- Gameplay is designed around short play sessions. The mini-games architecture promotes short-term goals, while the fast-paced renewal of word sets facilitates short reward cycles.
	- Support long play sessions.	- Longer play sessions are also supported since the gameplay will continue for as long as the player retains at least one life.
	- Promote short-term goals.	- Goals that have to do with gradual vocabulary building through repetition, are promoted via adaptable difficulty and statistics.

G3	Game easy to pick up and play	
<ul style="list-style-type: none"> - Game easy to learn (short or no tutorial). - Gradual on-boarding. - Game quick to access and start. 		<ul style="list-style-type: none"> - Game objective descriptions visible to support players. Objectives are easy to understand within a short time interacting with the system. - Gradual on-boarding is supported by adaptability, adjusting challenge to player skill. - The game is designed for speed and recovery, since it is easy to start and quick to return to after gameplay has been interrupted.

G4	Design for flexibility	
<ul style="list-style-type: none"> - Support interruptibility of gameplay. - Integrate auto-saving. - Return to previous game state, after pausing. - Foster variable levels of difficulty. 		<ul style="list-style-type: none"> - Interruptibility is supported since the player can easily stop the game anytime without losing progress. - Build in pause and auto-save functionality is implemented. - The above, allow the player to return to the previous state of the game after pausing. - Variation of difficulty levels via adaptability is supported, which makes the game accessible to a wide range of players.

G5	Gameplay positive and rewarding	
<ul style="list-style-type: none"> - Ensure initial success. - Short reward cycles. - Rewarding rather than punishing mechanics. - Foster the feeling of accomplishment. 		<ul style="list-style-type: none"> - The game fosters initial success since the difficulty of the challenge starts low and gradually builds up, along with the skill of the player. - Reward cycles are short, in the form of positive visual feedback provided with every correct set. - Reward is provided at the end of gameplay via the three stars mechanic. Punishment is minimised and restricted to loss of lives but not to reduction of score or achievement. - The feeling of accomplishment in the game is fostered via the three stars system, the high score and the statistics. It is also supported by real time positive visual feedback.

G6	Visual design appropriate	
	<ul style="list-style-type: none"> - Visual representations recognisable and easy to interpret. - Distinction between primary and secondary elements. - Visuals uncluttered, sharp and inviting. - Visual style consistent between mini-games/levels/devices. 	<ul style="list-style-type: none"> - The visual style is minimalistic, while visual references are easy to interpret. For each mini-game a distinctive colour was selected to provide a consistent visual theme. - White font is selected for text, to contrast the dark grey background. Colour contrast assists legibility and the distinction between primary and secondary elements. - Visuals are kept simple and gender neutral. The UI is uncluttered and plenty of negative space is used to make important content more noticeable. - UI elements are absolutely positioned between screens and the visual style remains consistent between mini-games.

The previous discussion demonstrated how the guidelines developed and presented earlier in this thesis apply to the design of the final version of the *Lexis* game prototype. The design of the game meets most of the criteria set by the guidelines for the development of effective, engaging, usable and pleasing mobile game-based learning. At the same time however, certain upgrades could be implemented in future versions of the game, as discussed next in this chapter.

7.3 Future Development

This final section of the chapter, briefly overviews possible areas of future development for *Lexis*. There are five upgrades that could be implemented in a future version including customisation, badges, exploration mode, social features and semantic distance adaptability.

Customisation – A future version of the game could benefit from customisation of both the content and the interface. Regarding content, it would be useful to allow players to choose learning materials by selecting the words or type of vocabulary they would like to learn. Choice over the learning materials would enhance learner-centred goals. With regards to game interface, customisation of colours and visual style could make the experience more personalised and fun. Additionally, since the player would be able to choose between different styles from a list of possibilities,

the preferences of a wider audience could be addressed (e.g. preference over a minimalistic or cartoonish design).

Badges – Enhancing player motivation via the use of badges is a common practice in mobile game design. Badges could be incorporated into the *Lexis* gameplay to signify the skill, progress and achievements of the player. A badge could be awarded for specific abilities (e.g. ‘master speller’ if ten subsequent words were spelled correctly in mini-game three). Badges could also assist on boarding upon first interaction with the system. Badges awarded could be listed in a dedicated achievements screen, where the player would be able to review the collection and see the ones still to collect.

Explore mode – This feature was suggested as a possible future development during the learning experts review. It was proposed that when the player responded in error in any of the mini-games along with feedback, more options could be provided including information about the word, examples of it being correctly used and resources for further reading (e.g. searching the web, on-line dictionary, etc). Technically, the implementation of this feature would require Internet connectivity at all times in order to be functional. It would however prompt the player to keep learning via further reading.

Social Features – As discussed earlier in this thesis (see section 6.1.1 Types of Games for Learning) the focus of the research is on individual rather than collaborative learning experiences. Future versions of *Lexis* could however, if focusing on collaborative learning, include the development of features like leader boards via interaction with the iOS Game Centre to allow for social and/or competitive dimensions to gameplay. Additionally in such a context, gameplay could become multiplayer via synchronous or asynchronous puzzle solving collaboration between players, which as a game mechanic could potentially foster engagement via sharing, the pursuit of joint objectives and team dynamics.

Semantic distance adaptability – Though adaptability is implemented in the game and challenge is in synchronisation with the skill of the player, an additional feature could be added to make the game more challenging to advanced players. The better the player does the closer the semantic distance between the words to choose from could become. So in any of the mini-games, as the difficulty of the challenge increases, words to choose from could appear closer in meaning. If commonly confused words were therefore to be used as alternatives for the same set, the harder the player would have to think and the more ability he/she would have to have in order to distinguish between them.

This chapter begun by overviewing the applicability of the design guidelines developed in Chapter 5 (Developing Design Guidelines for mGBL) to the design of *Lexis*. It then moved on to discuss the development of the initial version of the game and described the evaluative process adopted to inform the development of the final version. The following chapter will move on to discuss the evaluation of *Lexis*, which was conducted with users and determined the effectiveness of the game to support skill building in adults.

Chapter 8

Evaluation

This chapter presents the final contribution of the research, which is an evaluation of the mobile learning game prototype *Lexis*. The ways in which the learning effectiveness of mobile game-based applications could be evaluated will therefore be discussed. In the context of mobile games, as with any new learning technology, it is important to consider the learning experience and its impact, as well as the attitudes of the learners towards it. The purpose of evaluating *Lexis* was to therefore examine whether it met the intended outcomes, in order to assess the effectiveness of its design based on the guidelines for mobile game-based learning synthesised and presented in Chapter 5 (Developing Design Guidelines for mGBL), and to also gather qualitative data on the attitudes of players and their experience using the system.

The first section of the chapter begins to discuss ways of assessing the effectiveness of mobile learning games and then moves on to examine key issues to be taken into consideration when evaluating mobile learning in general. A case is made towards evaluating engagement and usability instead of direct learning, in order to assess the effectiveness of a mobile game-based learning application. Furthermore, since there is no consensus on the evaluation methods for such applications, a mixed methods approach utilising both quantitative and qualitative measures was adopted and is described in the next sections of the chapter. The findings of the two types of evaluation conducted for *Lexis*, a quantitative evaluation involving fifty (50) participants and a qualitative one performed with twenty (20) participants, are then presented and discussed. The next section of this chapter moves on to describe an initial investigation of possible indications of learning, while the final section summarises findings and discusses results.

8.1 Evaluating Lexis

One of the main aims of this research was the evaluation of the developed game prototype *Lexis*. Gathering data from evaluation was thus considered crucial to assess the design and also to provide insight into the effectiveness of game-based learning. This was particularly important since research in the area of game-based learning is limited and thus gathering data to support its employment is useful to the research community (Whitton, 2010). The first step to evaluate *Lexis* was to consider possible evaluation methods, which were appropriate for the context. However, designing assessment activities that are fit for purpose and that effectively examine learning undertaken in a mobile game is not always straightforward, especially due to the absence of one universal methodology for the evaluation of mobile game-based learning.

8.1.1 Evaluation of mGBL

When examining the literature, it appears that no one method of evaluation for game-based learning exists (Connolly et al., 2009). However, the methodological approach often employed seems to be pre-/post-tests and is usually used in the form of surveys or questionnaires. Using a pre-test before a gameplay session, followed by the intervention and then followed by a post-test afterwards is a method commonly used in experimental design to measure the effectiveness of an educational tool (Whitton, 2010). Furthermore, general experimental designs of studies evaluating game-based learning are often based on a pre/post test approach (Maguire et al., 2006). Using pre-/post-tests makes it possible to draw conclusions on increased learning via the comparison of scores between the tests. However in the case of *Lexis*, a pre-/post-test method was not considered suitable since though the activity was knowledge-based, solely measuring the memorisation of the vocabulary was considered to be a small part of the larger learning objective, which focused on higher level outcomes of enhancing the use of academic words in verbal and written communication involving a deeper understanding of meaning and context, problem-solving and association.

Furthermore, this decision was supported when considering the challenges posed by conducting a post-test that considered proper timing to account for the retention of vocabulary over time and the application of that vocabulary to other contexts, especially since the game was designed to be played more than once. Whitton (2010) also indicates some pragmatic challenges of the pre/post test approach including the difficulty to persuade participants to give up the extra time required to complete both tests as well as the difficulty of ensuring they will return to complete the test after some time, especially when examining retention of learning over a period of time. As an assessment method, the pre-/post-test is particularly useful for evaluating direct learning achieved in the game by testing the knowledge of the learning content.

After further consideration it was decided that the best approach for evaluating the game prototype would be assessing engagement and usability instead of learning from the game directly. This decision was influenced by literature on game-based learning supporting links between levels of engagement with a game and learning from it (Lepper and Malone, 1987; Jacques et al., 1995; Whitton, 2010). In adopting this approach it was important to highlight that assuming learning outcomes were aligned with game outcomes, engagement with the game could imply engagement with the learning content as well. On that direction, it was considered that applying the design guidelines presented in Chapter 5 (Developing Design Guidelines for mGBL) to the design of *Lexis*, should allow the inference that learning and game outcomes were aligned as far as possible. Therefore, the measurement of engagement with a game-based learning experience was a way of gaining insight into its effectiveness for learning (Whitton, 2010).

In addition to examining engagement however, it was important to also assess the usability of the system, which would allow an evaluation of the user experience. Literature on Human-Computer Interaction (HCI) assumes usable systems and devices are those that are easy to learn, effective to use, efficient and enjoyable from the user's perspective (Nielsen, 1994). Usability influences whether learning is an engaging experience and thus it will have an impact on the effectiveness and efficiency of learning. Therefore, from a pedagogical perspective it is about ensuring

the educational experience is good and enables successful interactions (Kukulska-Hulme, 2005). It is therefore important to ensure that any learning technology provides a good overall user experience and invites, rather than discourages, users from using the system. Kukulska-Hulme and Shield (2004) claim that technical usability is the basis for a successful learning experience though not sufficient in itself. It is therefore argued that usability aspects such as the accessibility, consistency and reliability of the system can enhance engagement and therefore learning. Furthermore, when evaluating microlearning systems, usability approaches may be useful since applying quantitative evaluations or controlled experiments to assess informal or lifelong learning processes would be particularly difficult (Gabrielli et al., 2006). It is therefore argued that since in the context of mobile microlearning, direct evaluation of informal and lifelong learning is difficult, an alternative approach would be to evaluate engagement and usability instead.

By establishing a reasonable case for *Lexis* being engaging and usable, it could therefore be inferred that learning would be facilitated while using the system, while it would also help to validate the overall design effectiveness. At the same time though it was important to gain an insight into the appropriateness of the game for the context and to draw empirically derived conclusions on the perceptions and attitudes of adult learners. Thus, the foundation upon which the evaluation was based was that in the event that the game was engaging and usable and the attitudes of the learners towards using it were positive, leading them to keep coming back to it, learning could be achieved. A mixed media data collection methodology was therefore employed for the final evaluation of *Lexis*. A quantitative and a qualitative evaluation were conducted to gather both more generalisable and more in-depth data about the game. The two stages of evaluation along with the data collected are discussed later in this chapter.

8.1.2 Mobile Specific Evaluation Considerations

Before evaluating *Lexis*, it was important to examine mobile specific evaluation considerations to inform the design of the assessment activities. *Lexis* is a mobile

learning game, thus certain challenges relevant to the evaluation of mobile learning apply and should be considered.

The first challenge in evaluating mobile learning is the assessment of the learning outcomes. This is due to the lack of a well-established method for assessing mobile learning activities, which are on-going lifelong processes (Vavoula and Sharples, 2009). Additionally if this learning is informal and personally initiated, it is difficult to predict where it will take place and the outcomes it will lead to. Mobile learning blurs the distinctions between formal and informal learning so traditional assessment methods are not always appropriate (Sharples et al., 2009). To that end, Vavoula and Sharples (2009) propose an alternative approach to evaluating mobile learning, which is examining the experience for evidence that might suggest learning is taking place. This approach supports the evaluation methods adopted for *Lexis*, as discussed in the previous section of this chapter, according to which engagement is assessed as a possible indicator of learning. Another option is to focus on the learners' perceptions of the learning experience via attitude surveys, though standardised instruments have not yet been developed (Vavoula and Sharples, 2009). For the evaluation of *Lexis*, the attitudes of the learners towards the game were examined via qualitative instruments, including think-aloud and an interview. Furthermore, technology poses an additional challenge to the evaluation of mobile learning, thus assessing usability and the effectiveness of the integration of technology with the mobile learning practice is a high priority (Vavoula and Sharples, 2009). Again, as previously discussed, usability was one of the elements assessed during the evaluation of *Lexis*, recognising the importance of a smooth user experience for mobile game-based learning.

Another challenge for the evaluation of mobile learning is context. In comparison to other learning technologies, mobile devices are portable, thus the learning context is not static. The context of use for mobile learning can vary significantly in terms of ergonomics, social context and demands on user attention (Sharples et al., 2009). It is therefore important to consider that since context is not fixed, it may not be well defined which makes it difficult to observe and analyse. Vavoula and Sharples

(2009) discuss levels of ambiguity when evaluating mobile learning, indicating personal mobile learning as being the most unpredictable in terms of setting and processes. Recent research has focused on the examination of specific methods that are appropriate for analysing mobile learning contexts, each of which may require different evaluation methods. Increasingly however, mobile evaluation designs include mixed methods for validating data and for capturing different perspectives of the learning experience (Vavoula and Sharples, 2009). For the evaluation of *Lexis*, a mixed methods evaluation approach was adopted, employing both quantitative and qualitative methods such as play testing, think-aloud, questionnaires and interviews. Due to increased vagueness, since mobile learning was personal and took place on individually owned devices, it was decided not to monitor learning across contexts but to focus on the learner's perceptions of the experience via examining attitudes and predicted patterns of usage. User evaluation was therefore conducted in the form of testing events. Literature on user testing for mobile applications supported testing events, since no significant difference was found between laboratory and field-testing with regards to where to test the mobile application (Kaikkonen et al., 2005). This decision was also informed by pragmatic constraints such as time and the resources available, which did not allow observation over time. To collect data on learners' perceptions and attitudes, an inquiry based solution was adopted through interviews (Vavoula, 2005), as well as a think aloud protocol, which was found to be the best alternative to gathering data during user testing (Kaikkonen et al., 2005). It has been suggested that future work could focus on evaluation across contexts via allowing testers to take the game away on their mobile devices while their playing patterns are monitored over a period of time.

With regards to evaluating mobile learning, Vavoula and Sharples (2009) propose a framework comprising of a micro level evaluation concerned with usability, a meso level concerned with the learning experience and a macro level concerned with integration within existing educational and organisational institutions. This three-level framework was developed in the context of a project called Myartspace, which supported structured inquiry learning via technology that connected learning in the classroom with learning in museums and galleries. Although the mobile learning

context of Myartspace is different to that of *Lexis*, the framework can be transferable to an extent and was therefore considered interesting to examine in comparison to the evaluation approaches adopted for the game prototype. According to Vavoula and Sharples (2009), the framework places evaluation at the centre of development and can be used from the early stages of design to a final assessment of the deployed technology in use, following the lifecycle approach to educational technology evaluation, proposed by Meek (2006). The three-level framework structures the evaluation planning around general goals for assessing usability, educational effectiveness and overall impact (Sharples et al., 2009). Following, the three levels are presented along with their descriptions and applicability to the evaluation methods adopted for *Lexis*:

Level	Description	Evaluation Activities for Lexis
Micro level	Examines the individual activities of the technology users and assesses the usability and utility of the educational technology system.	<ul style="list-style-type: none"> - Quantitative Usability Questionnaire - Think aloud while play testing - Interview
Meso level	Examines the learning experience as a whole, to identify learning breakthroughs and breakdowns. It also assesses how well the learning experience integrates with other related activities and experiences.	<ul style="list-style-type: none"> - Quantitative Engagement Questionnaire - Time on task - Interview
Macro level	Examines the impact of the new technology on established educational and learning practices and institutions.	<ul style="list-style-type: none"> - Interview (impact on adult's daily life)

Table 8-1: Three-level evaluation framework (adapted from Vavoula & Sharples, 2009)

Looking at the above table, the connection between each level of evaluation and the methods used for the evaluation of *Lexis* are visible. Overall the evaluation stages of the game prototype comply with the guidelines proposed by the framework regarding the evaluation of usability, learning experience and impact. A difference in the evaluation approach can be identified in the meso level, where engagement is assessed as an indicator of the learning experience in the case of *Lexis*. Additionally, the guideline of impact examination of the technology on established educational learning practices and institutions on the macro level, does not apply in the case of

Lexis and so the impact on the adult's life is considered instead. As discussed in Chapter 3 (section 3.3 Limitations of the Study), however, long-term impact was not examined since qualitative evaluation was conducted immediately after play testing the game once, and thus attitudes and intentions were monitored instead of solid beliefs.

So far throughout this chapter considerations and initial decisions on the evaluation methodology of *Lexis* have been discussed. The following sections move on to describe the quantitative and qualitative evaluation that took place, as well as the specific instruments used and the results of the analysis of the collected data.

8.2 The Quantitative Evaluation

The first step to data collection for the evaluation of *Lexis* was the examination of the individual attitudes of participants regarding the experience, focusing on engagement and usability. The aim was to examine whether the game was both engaging and usable. Participants who undertook the quantitative study were asked to play *Lexis* and then complete a questionnaire. The questionnaire was felt to be an appropriate measuring tool, since it asked every participant to think about the activity and answer questions based on their own personal perceptions of the game experience. Surveying participants is a common evaluation instrument used in the majority of game-based evaluations encountered in the research literature (Connolly et al., 2009). Data collected from the questionnaire would then be complemented by qualitative data to be gathered in the next stage of evaluation, as described in the following section of this chapter.

Fifty (50) participants were recruited to take part in the quantitative evaluation. Participants were recruited via calls for participations within the schools of Edinburgh University, via word of mouth and through the researcher's professional connections. They therefore represented a mixed group made up of students, researchers and professionals. Participants came from a range of academic and professional backgrounds, which were not necessarily design related; the majority

therefore did not have previous experience with evaluation practices in a similar context. All of the participants recruited were adults between 21-39 years old, non-native speakers of English, who were familiar with the system (mobile phone owners for more than three months). They self-identified their level of English competence as intermediate to advanced, however as discussed in Chapter 3 (Methodology), this variable was not controlled.

Though this research is targeted at the general population of adult learners, it was decided to narrow down the scope to a more specific age group for pragmatic reasons. The selected age range was adults between 21 and 39 years old, as previously mentioned. The decision to select this particular group was informed by the results of the background study as described in Chapter 4 (Background Study), where the two most represented age groups in the online survey were 21-29 year olds at 46% of the population and 30-39 year olds at 32%. Furthermore, the particular demographic of adults between ages 20 and 40 years of age, born between the mid-1970s and the 1990s, alongside the rise of early commercial video games such as Pong (1974), Star Wars (1977) and Space Invaders (1978), fall into the millennials categorisation and can be considered as members of the games generation (Prensky, 2001), having grown up playing or at least being accustomed to the idea of video games.

The evaluation session lasted for approximately half an hour for each participant. During this time the participant was initially introduced to the process of the experiment and the game, while he/she was informed about the overall aim of the study and asked to complete a consent form (see Appendix B.3). Next the participant played the game freely for as long as he/she felt engaged to do so and was then asked to complete a post experience questionnaire. This questionnaire was made up of three sections, each featuring a number of questions: seven (7) introductory demographics questions, eighteen (18) questions measuring engagement and sixteen (16) questions measuring usability. The development stages of the questionnaire as well as the data collected are discussed below.

The first section of the questionnaire involved introductory questions on participants' demographics. Questions were based around the age, gender, familiarity with the device and mobile gaming habits of the participant.

Q.1 What is your age? *

☐ 21-39

☐ Other

Q.2 What is your gender? *

☐ Male

☐ Female

Q.3 Are you a native English speaker? *

☐ Yes

☐ No

Q.4 How long have you been owning a mobile phone? *

☐ Less than 3 months

☐ More than 3 months

Q.5 Do you play games on you mobile phone? *

☐ Yes, often

☐ Yes, occasionally

☐ Yes, rarely

☐ No, once or twice

☐ No, never

Q.6 If you do play games on your mobile phone, how often would you say you play? *

☐ More than once a day

☐ Once a day

☐ A few times per week

☐ Once a week

☐ A few times per month

☐ I never do

Q.7 Would you consider yourself a mobile gamer? *

☐ Yes

☐ No

Figure 8-1: Introductory questions of the quantitative questionnaire

Looking at the data gathered from the demographics section of the questionnaire, male and female participation in the study was balanced, with female participants

being slightly more represented. Overall, 23 participants were men (46%) and 27 were women (54%). Furthermore, all of the participants (100%) were between 21 and 39 years old, non-native speakers of English and had been owners of a mobile device for more than three months prior to taking part in the experiment.

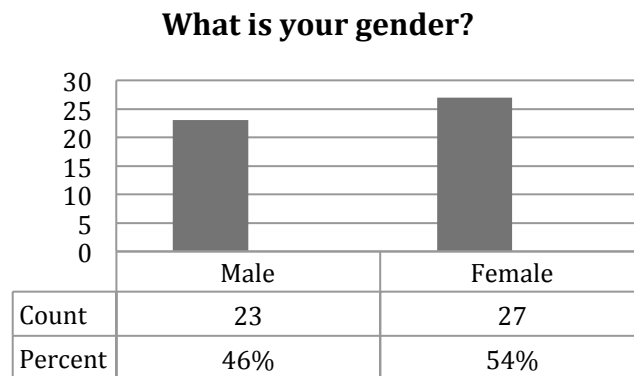


Figure 8-2: Male to female participation

A total of 38% said that they played games on their mobile phones occasionally, while 26% played often and 22% rarely played. In comparison, a total of 14% indicated that they do not play games on their mobile phone, with 6% saying they had played once or twice and 8% never playing. The results are consistent with those gathered during the large-scale online questionnaire (Chapter 3: Background Study). In both the background study and the quantitative questionnaire, 92% of respondents indicated that they had played a game on their mobile device at least once.

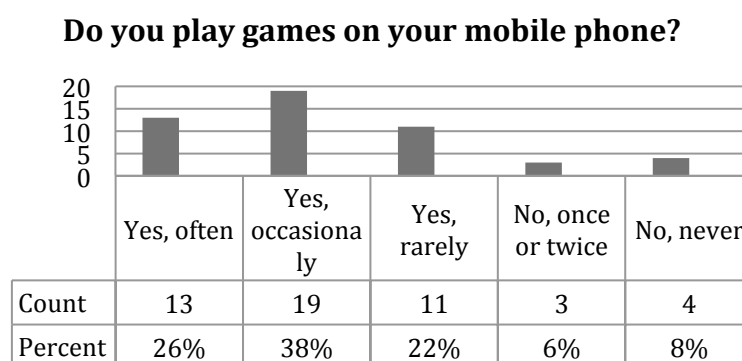


Figure 8-3: Mobile gameplay habits indicated by participants

Participants were then asked how often they played games on their mobile phones. The majority indicated that they played a few times per week (30%), or a few times per month (24%), followed by those who played once a week (16%). A total of 20% indicated that they played often, with 12% of them playing more than once a day and 8% playing once a day. Finally, 10% of participants said that they never played.

Interestingly, comparing these results with those gathered to a similar question during the background study as described in Chapter 4 (Background Study), they seem to be consistent. In the background study, 17% of participants said they played more than once a day, 15% once a day, 23% a few times per week, 7% once a week and 21% a few times per month. Respectively during the quantitative study, the percentages for the same answers were: 12% played more than once a day, 8% once a day, 30% a few times per week, 16% once a week and 24% a few times per month.

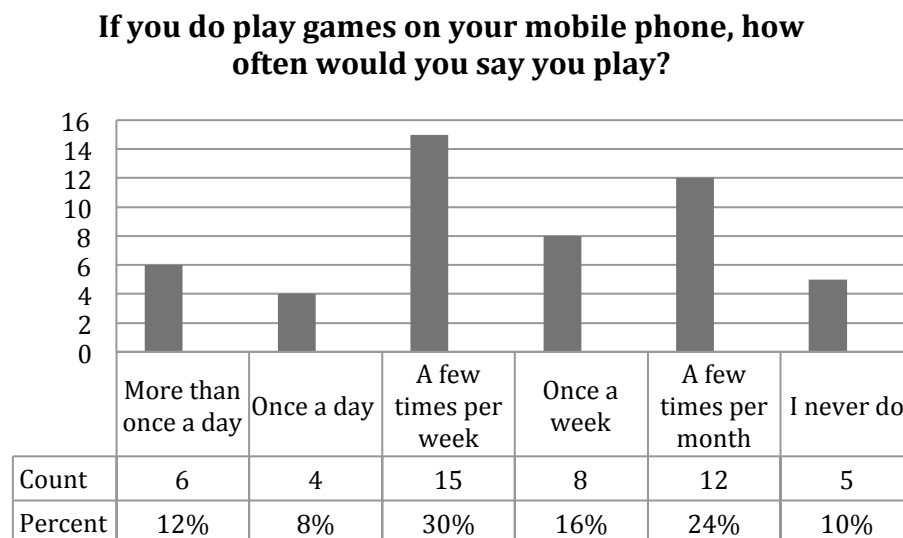


Figure 8-4: Frequency of mobile play sessions

Finally, participants were asked whether they considered themselves to be mobile gamers. Here the majority replied negatively, with 70% of participants saying that they did not consider themselves as mobile gamers, in comparison to 30% who replied that they did. This result signifies that although mobile phone users may play games on their devices, they do not necessarily self-identify as mobile gamers. Again, here there is a connection to the results of the background study (Chapter 4),

where playing on a mobile device seemed to appeal to those who did not necessarily consider themselves as gamers or did not necessarily play on other platforms. It appears therefore that though someone may not self-identify as a gamer, they may still play games on their mobile device with varying degrees of frequency, which supports the hypothesis that mobile games have the potential to be appealing to a wider and more diverse range of audiences.

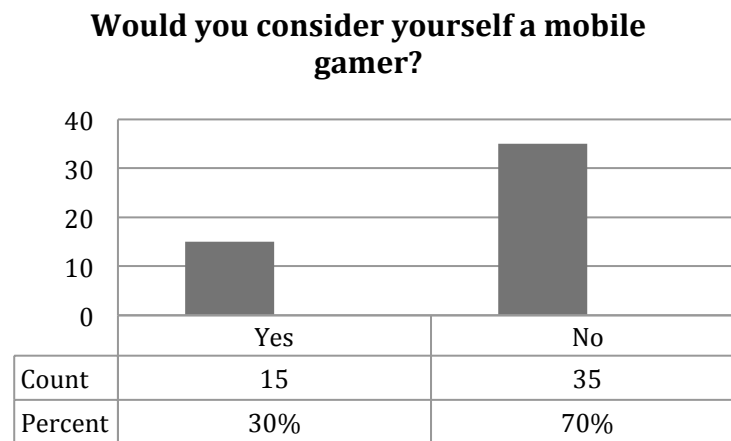


Figure 8-5: Self-identification of mobile gamer status

The second section of the questionnaire involved questions on engagement. To measure the level of engagement for *Lexis*, an engagement questionnaire for game-based learning developed by Whitton (2010, p. 112) was adopted. The questionnaire is made up of eighteen (18) Likert scale questions and is intended as a tool for the measurement of the levels of engagement with a particular learning experience or the comparison between two learning activities. The questionnaire was originally developed based on key theories on games, learning and engagement (Csikszentmihalyi, 1992; Malone, 1980a; Knowles, 1998), which have also informed the theoretical background of this research as well as the development of the guidelines for mobile game-based learning presented in Chapter 5 (Developing Design Guidelines for mGBL). Whitton's engagement questionnaire (2010) has been fully adopted here, with the exception of three out of the eighteen questions, which have been removed from this section on engagement and incorporated in the next section on usability.

These following three questions were considered more appropriate to be incorporated in the usability section, since they were felt to be more relevant to functionality and the user's experience with the system:

1. It wasn't clear what I could and couldn't do.
2. The activity would not let me do what I wanted.
3. I could not tell what effect my actions had.

The above three questions were replaced by a general engagement question for each of the mini-games, resulting in a total of eighteen questions for the section. The final quantitative questionnaire used for this research can be seen below.

Engagement Questionnaire (Whitton, 2010)	Engagement Questions (Quantitative Study)
I wanted to complete the activity	I wanted to complete the activity
I found the activity frustrating	I found the activity frustrating
I felt that I could achieve the goal of the activity	I felt that I could achieve the goal of the activity
I knew what I had to do to complete the activity	I knew what I had to do to complete the activity
I found the activity boring	I found the activity boring
It wasn't clear what I could and couldn't do	It was clear what I could learn from the activity
It was clear what I could learn from the activity	I felt absorbed in the activity
I felt absorbed in the activity	The activity was pointless
The activity was pointless	I was not interested in exploring the options available
I was not interested in exploring the options available	I did not care how the activity ended
I did not care how the activity ended	I felt that time passed quickly
I felt that time passed quickly	I found the activity satisfying
I found the activity satisfying	I did not enjoy the activity
The activity would not let me do what I wanted	Feedback I was given was useful
I could not tell what effect my actions had	I found it easy to get started
I did not enjoy the activity	I found mini-game 1 (WORDPICK) engaging
Feedback I was given was useful	I found mini-game 2 (PHRASEGAP) engaging
I found it easy to get started	I found mini-game 3 (LETTERSPELL) engaging

Table 8-2: Original engagement questionnaire (Whitton, 2010) and final adapted questionnaire

The second section of the questionnaire featuring the above questions, as it appeared in the final survey used for the quantitative evaluation, can be seen in the following image:

Q.8 Keeping in mind the play test you just had, please answer the following questions. *

	Stongly disagree	Disagree	Neither Agree, nor disagree	Agree	Strongly agree
I wanted to complete the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the activity frustrating	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt that I could achieve the goal of the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I knew what I had to do to complete the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the activity boring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was clear what I could learn from the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt absorbed in the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The activity was pointless	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I was not interested in exploring the options available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I did not care how the activity ended	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt time passed quickly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found the activity satisfying	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I did not enjoy the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feedback I was given was useful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found it easy to get started	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found mini-game 1 (WORD PICK), engaging	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found mini-game 2 (PHRASE GAP), engaging	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I found mini-game 3 (LETTER SPELL), engaging	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 8-6: Quantitative questionnaire (engagement)

Data collected from the Likert scale questionnaire on engagement were encouraging. Overall it appeared as though *Lexis* was engaging to participants who undertook the evaluation. The following graph presents the response rates for each of the questions in the engagement questionnaire.

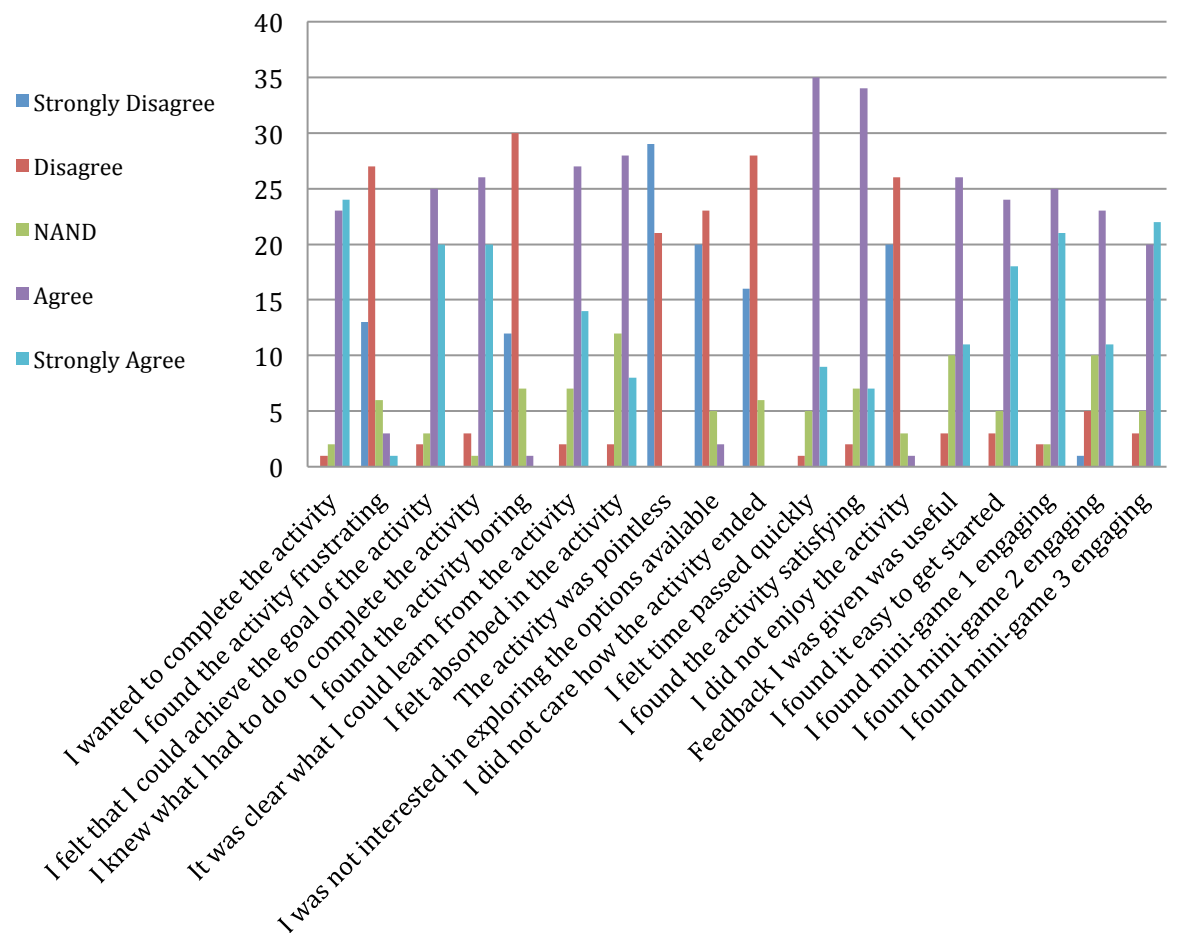


Figure 8-7: Overview of the results of the engagement questionnaire

The following two tables provide more detailed reports on the collected quantitative data. The first table (8-3) presents a summary of participants' responses in the form of the overarching percentage for each question, as well as the average Likert scale score, where weighting is assigned from (1) Strongly Disagree to (5) Strongly Agree. The second table (8-4) provides a basic statistical description in the form of a heat map and presents the number of responses out of the total for each weight. The average Likert scale score is also provided.

Question	Strongest Percentage	Average
I wanted to complete the activity	48% Strongly Agree and 46% Agree	4.4
I found the activity frustrating	54% Disagree and 26% Strongly Disagree	2.04
I felt that I could achieve the goal of the activity	50% Agree and 40% Strongly Agree	4.26
I knew what I had to do to complete the activity	52% Agree and 40% Strongly Agree	4.26
I found the activity boring	60% Disagree and 24% Strongly Disagree	1.94
It was clear what I could learn from the activity	54% Agree and 28% Strongly Agree	4.06
I felt absorbed in the activity	56% Agree and 24% NAND	3.84
The activity was pointless	58% Strongly Disagree and 42% Disagree	1.42
I was not interested in exploring the options available	46% Disagree and 40% Strongly Disagree	1.78
I did not care how the activity ended	56% Disagree and 32% Strongly Disagree	1.8
I felt that time passed quickly	70% Agree and 18% Strongly Agree	4.04
I found the activity satisfying	68% Agree and 14% Strongly Agree	3.92
I did not enjoy the activity	52% Disagree and 40% Strongly Disagree	1.7
Feedback I was given was useful	52% Agree and 22% Strongly Agree	3.9
I found it easy to get started	48% Agree and 36% Strongly Agree	4.14
I found mini-game 1 engaging	50% Agree and 42% Strongly Agree	4.3
I found mini-game 2 engaging	46% Agree and 22% Strongly Agree	3.76
I found mini-game 3 engaging	44% Strongly Agree and 40% Agree	4.22

Table 8-3: Strongest percentage and average for each engagement question

Question	Strongly Disagree	Disagree	NAND	Agree	Strongly Agree	Average
I wanted to complete the activity	0	1	2	23	24	4.4
I found the activity frustrating	13	27	6	3	1	2.04
I felt that I could achieve the goal of the activity	0	2	3	25	20	4.26
I knew what I had to do to complete the activity	0	3	1	26	20	4.26
I found the activity boring	12	30	7	1	0	1.94
It was clear what I could learn from the activity	0	2	7	27	14	4.06
I felt absorbed in the activity	0	2	12	28	8	3.84
The activity was pointless	29	21	0	0	0	1.42
I was not interested in exploring the options available	20	23	5	2	0	1.78
I did not care how the activity ended	16	28	6	0	0	1.8
I felt that time passed quickly	0	1	5	35	9	4.04
I found the activity satisfying	0	2	7	34	7	3.92
I did not enjoy the activity	20	26	3	1	0	1.7
Feedback I was given was useful	0	3	10	26	11	3.9
I found it easy to get started	0	3	5	24	18	4.14
I found mini-game 1 engaging	0	2	2	25	21	4.3
I found mini-game 2 engaging	1	5	10	23	11	3.76
I found mini-game 3 engaging	0	3	5	20	22	4.22

Table 8-4: Number of responses for each weight and average for each engagement question

Looking at the above collected data it becomes obvious that a clear majority of participants wanted to complete the activity (94%) and felt that time passed quickly during play (88%), while it was clear to them what they could learn from the game (82%). Furthermore, they found it easy to get started (84%) and felt that they could achieve the goal of the game (90%). They also enjoyed the activity (92%) and did not find it to be boring (84%). Very interesting is the fact that all of the participants responded positively regarding the value of the activity, which they did not find to be pointless (100%). Finally, all of the three mini-games appeared to be engaging. Mini-game 1 appeared to be the most engaging amongst participants (92%), followed by mini-game 3 (84%) and mini-game 2 (68%), which was the least engaging of the three.

The third and final section of the questionnaire involved questions on the usability of *Lexis*. Having previously examined engagement, the next important step was to assess the design of the application and the overall user experience. A sixteen (16) question Likert scale questionnaire was developed according to the usability guidelines proposed in Chapter 5 (Developing Design Guidelines for mGBL), based on key theories on game usability and mobile interface design (Nielsen, 1994; Malone 1980a, 1980b, 1982; Federoff, 2002; Koivisto & Korhonen, 2006), which inform the theoretical background of this research. Once compiled, the questions were informally tested with a small number of perspective users to confirm clarity. Additionally, the three questions previously removed from the engagement questionnaire (Whitton, 2010) were incorporated in the usability section, as presented below:

Usability Questions (Quantitative Study)	Usability Guideline Associated with (Chapter 5)
I found it easy to use the system	U1: Multiple contexts support
It wasn't clear what I could and couldn't do	(Whitton, 2010)
I could not tell what effect my actions had	(Whitton, 2010)
The system would not let me do what I wanted	(adapted from Whitton, 2010)
Navigation was easy	U3: Intuitive controls
The system responded to my actions	U4: Game responsive
Feedback I was given was clear	U5: Goals and progress clear
Game screens felt crowded	U2: Screen layout efficient, uncrowded and pleasing
Information I needed during play was clearly visible	U2: Screen layout efficient, uncrowded and pleasing
Visual design between mini-games felt consistent	U2: Screen layout efficient, uncrowded and pleasing
Game controls were intuitive	U3: Intuitive controls
I could see my progress in the game	U5: Goals and progress clear
I felt confident using the system	U6: Player should feel in control
It was easy to understand the objective of mini-game 1 (WORD PICK)	U5: Goals and progress clear
It was easy to understand the objective of mini-game 2 (PHRASE GAP)	U5: Goals and progress clear
It was easy to understand the objective of mini-game 3 (LETTER SPELL)	U5: Goals and progress clear

Table 8-5: Usability questions and associated usability guidelines

The third and final section of the questionnaire, as it appeared in the final survey used for the quantitative evaluation of *Lexis*, can be seen in the following image:

Q.9 Keeping in mind the play test you just had, please answer the following questions. *

	Stongly disagree	Disagree	Neither Agree, nor disagree	Agree	Strongly agree
I found it easy to use the system	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It wasn't clear what I could and couldn't do	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could not tell what effect my actions had	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The system would not let me do what I wanted	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Navigation was easy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The system responded to my actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feadback I was given was clear	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Game screens felt crowded	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Information I needed during play was clearly visible	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Visual design between mini-games felt consistent	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Game controls were intuitive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I could see my progress in the game	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt confident using the system	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was easy to understand the objective of mini-game 1 (WORD PICK)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was easy to understand the objective of mini-game 2 (PHRASE GAP)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It was easy to understand the objective of mini-game 3 (LETTER SPELL)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 8-8: Quantitative questionnaire (usability)

The data collected from the Likert scale questionnaire on usability were also encouraging. Overall it appeared as though *Lexis* was usable and offered a positive user experience to the participants who undertook the evaluation. The following graph presents the response rates for each of the questions in the usability questionnaire.

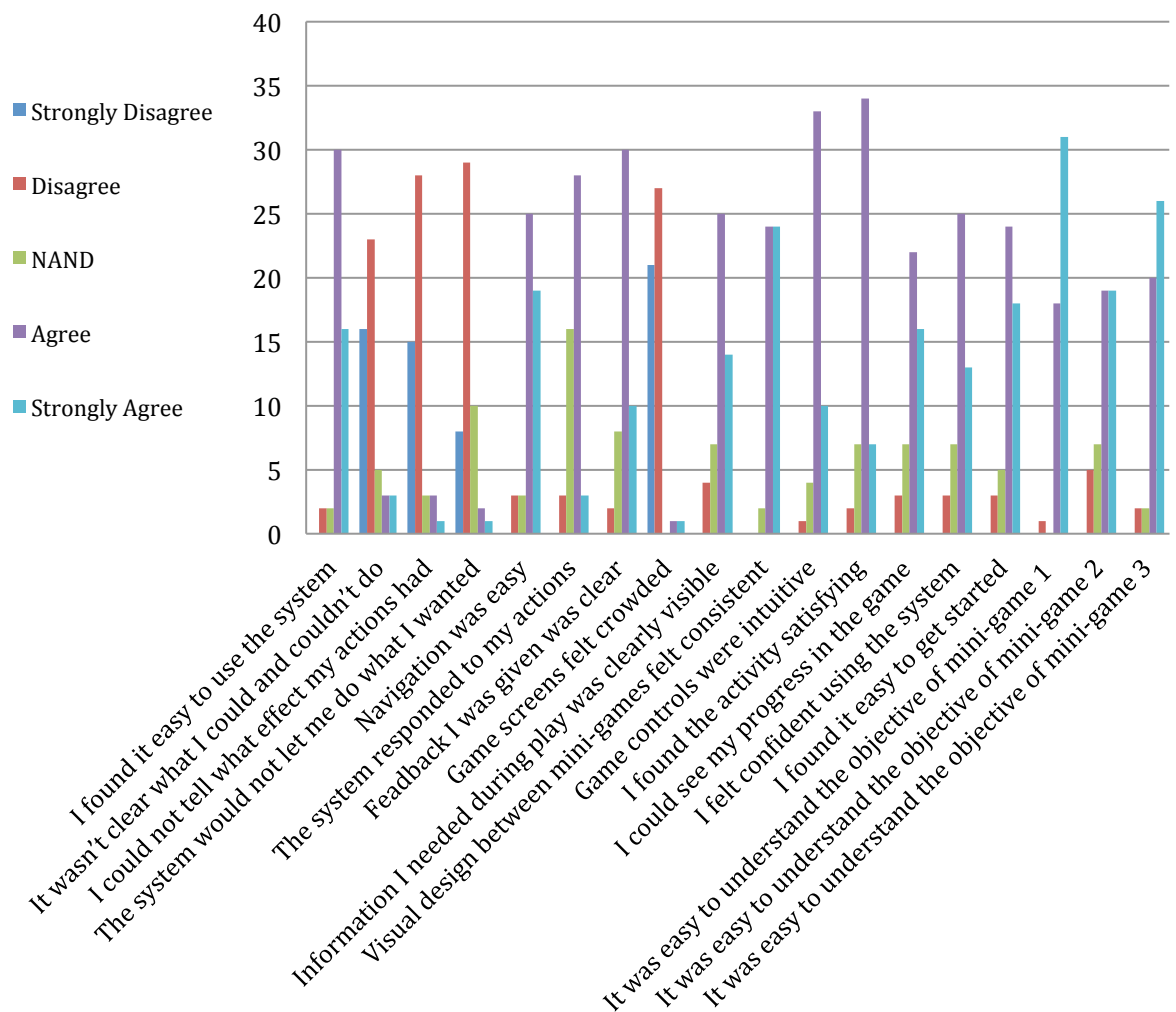


Figure 8-9: Overview of the results of the usability questionnaire

Looking at the collected data in more detail, conclusions can be drawn on the overall user experience and the usability of the system. The following two tables provide more detailed reports on the collected quantitative data. The first table (8-6) presents a summary of participants' responses in the form of the overarching percentage for each question, as well as the average Likert scale score, where weighting is assigned from (1) Strongly Disagree to (5) Strongly Agree. The second table (8-7) provides a basic statistical description in the form of a heat map and presents the number of responses out of the total for each weight.

Question	Strongest Percentage	Average
I found it easy to use the system	60% Agree and 16% Strongly Agree	4.2
It wasn't clear what I could and couldn't do	46% Disagree and 32% Strongly Disagree	2.08
I could not tell what effect my actions had	56% Disagree and 30% Strongly Disagree	1.94
The system would not let me do what I wanted	58% Disagree and 20% NAND	2.18
Navigation was easy	50% Agree and 38% Strongly Agree	4.2
The system responded to my actions	56% Agree and 32% NAND	3.62
Feedback I was given was clear	60% Agree and 20% Strongly Agree	3.96
Game screens felt crowded	54% Disagree and 42% Strongly Disagree	1.68
Information I needed during play was clearly visible	50% Agree and 28% Strongly Agree	3.98
Visual design between mini-games felt consistent	48% Agree and 48% Strongly Agree	4.44
Game controls were intuitive	68% Agree and 20% Strongly Agree	4.08
I could see my progress in the game	45% Agree and 33% Strongly Agree	4.06
I felt confident using the system	52% Agree and 27% Strongly Agree	4
It was easy to understand the objective of mini-game 1	62% Strongly Agree and 36% Agree	4.58
It was easy to understand the objective of mini-game 2	38% Agree and 38% Strongly Agree	4.04
It was easy to understand the objective of mini-game 3	52% Strongly Agree and 40% Agree	4.4

Table 8-6: Strongest percentage and average for each usability question

Question	Strongly Disagree	Disagree	NAND	Agree	Strongly Agree	Average
I found it easy to use the system	0	2	2	30	16	4.2
It wasn't clear what I could and couldn't do	16	23	5	3	3	2.08
I could not tell what effect my actions had	15	28	3	3	1	1.94
The system would not let me do what I wanted	8	29	10	2	1	2.18
Navigation was easy	0	3	3	25	19	4.2
The system responded to my actions	0	3	16	28	3	3.62
Feedback I was given was clear	0	2	8	30	10	3.96
Game screens felt crowded	21	27	0	1	1	1.68
Information I needed during play was clearly visible	0	4	7	25	14	3.98
Visual design between mini-games felt consistent	0	0	2	24	24	4.44
Game controls were intuitive	0	1	4	33	10	4.08
I could see my progress in the game	0	3	7	22	16	4.06
I felt confident using the system	0	3	7	25	13	4
It was easy to understand the objective of mini-game 1	0	1	0	18	31	4.58
It was easy to understand the objective of mini-game 2	0	5	7	19	19	4.04
It was easy to understand the objective of mini-game 3	0	2	2	20	26	4.4

Table 8-7: Number of responses for each weight and average for each engagement question

From the above data it appears as though the majority of participants found it easy to use the system (76%) and thought that the controls were intuitive (88%), while they could see their progress in the game (78%) and understand what effects their actions had (86%). Regarding the interface, participants found that the visual design between mini-games felt consistent (96%) and that game screens did not feel crowded (96%). On the other hand, although the percentage of positive responses was still the overarching one, the 'Neither Agree Nor Disagree' responses were slight raised for the 'system did not let me do what I wanted' question (20%) and the 'system responded to my actions' question (32%). This was anticipated since there was a known issue with the sensitivity of tapping input in the testing device, which was especially noticeable in the third mini-game, which may have slightly affected the results.

The overall data collected from the quantitative study described above, were encouraging and provided an indication that *Lexis* was engaging and usable. The majority of participants seemed to have found the game enjoyable and easy to use, while they recognised the learning value of the activity and perceived that they could meet the outcomes. It was however felt that although the results were encouraging, the quantitative measures were not sufficient and that qualitative data were also required to evaluate learners' experiences and their perceptions of learning with mobile games.

8.3 The Qualitative Evaluation

The second step in the evaluation of *Lexis* was a large scale qualitative review, involving twenty (20) participants who in addition to undertaking play testing and completing the quantitative questionnaire were asked to conduct think aloud, a time on task experiment, and an interview. The qualitative review was considered important since although some aspects of the evaluation of *Lexis* were suitable for quantitative assessment, others such as the participants' experiences, perceptions and attitudes, were not suited to quantitative measures.

John Creswell (Creswell, 2003, p. 75) justifies the use of qualitative approaches in cases where an area is 'immature', but the phenomenon needs to be explored further and where quantitative measures are not suitable. Qualitative research methods are thus traditionally utilised in exploratory studies and under-researched fields (Creswell, 1998). The collection of qualitative data was therefore considered valuable to obtain a better understanding and description of *Lexis*.

The qualitative evaluation session lasted for approximately an hour for each participant. During this time the participant was initially introduced to the research aims and the processes of the experiment, while he/she was asked to complete a consent form (see Appendix B.4). Next the participant play tested the game conducting think-aloud to verbalise perceptions and expectations about the play experience and the usability/design of the system. Afterwards the participant was asked to play the game again, for as long as he/she felt engaged to do so, to conduct a time on task test. Finally, an interview with the researcher was conducted to discuss the experience and overall attitudes towards mobile game-based learning.

Observation took place while the participant undertook play testing and thinking aloud. The physical set-up of the evaluation session is presented below. The participant was seated at a desk holding the mobile testing device (iPhone) and played the game, while the researcher sat behind and to the right, taking notes. A laptop was positioned in front of the participant, remotely recording the screen of the mobile device using the airplay third party mirroring application X-Mirage. The position of the laptop and the seating arrangement allowed the researcher to see the laptop screen mirroring the screen of the testing device, and thus to observe in real time the participant's actions in the game. Finally, a microphone was connected to the laptop, digitally capturing audio. Observation during think aloud provided the chance for the researcher to examine gameplay as it happened and to take notes on any key insights verbalised by the participant.

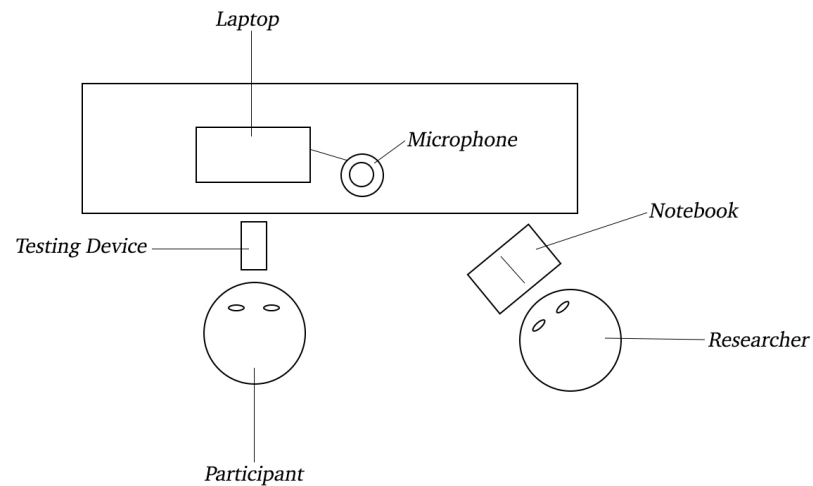


Figure 8-10: Physical set-up of qualitative evaluation session

Out of the fifty (50) participants who took part in the quantitative evaluation of *Lexis*, twenty (20) conducted the additional qualitative evaluation. Participant recruitment for the qualitative evaluation was conducted on a theoretical saturation basis, which could be defined as the continuation of sampling and data collection until no new conceptual insights are generated (Seale, 1999). No fixed sample size was therefore determined, but rather it was decided that after twenty evaluations a point was reached where no new significant information was obtained by the accumulation of further data, while patterns had started to emerge to allow empirically derived conclusions. Various methods were used during the evaluation sessions to gather qualitative data as previously discussed. Those methods along with the results obtained are further described below.

8.3.1 Think Aloud

The first step to the qualitative evaluation was the think aloud. Participants were asked to play the game, verbalising at the same time their thoughts about the play experience as well as the interface and functionality of the game. Think aloud is a method commonly used in usability evaluations to obtain insight into the user experience (Nielsen, 1995). When thinking aloud, testers usually talk about their

thoughts, expectations and perceptions while performing tasks on a particular application. During the think aloud evaluation of *Lexis*, the researcher sat next to participants, prompting them to keep talking and observing their performed actions. The think aloud session was audio recorded to assist later analysis, while notes were taken by the researcher while the play test took place. The aim of the think aloud was to get immediate feedback on the game functionality and design and to collect data on the user experience, extending those gathered during the quantitative evaluation. The themed findings are summarised below:

Think-aloud findings on the final version of <i>Lexis</i>	
System Easy to Use	All participants indicated that they found it easy to use the system. Frustration and/or surprise were not reported by any of the participants while using the system.
Clear Objectives	The objectives of mini-games 1 and 3 were clear for all participants. The objective of mini-game 2 was not immediately clear for every participant but became clear after a short interaction time with the system.
Logical Controls	None of the participants encountered major issues with game controls, which appeared to be logical. Single tapping as the only input method made the system accessible to both novice and advanced players. Unnecessary complexity was not reported by any of the participants, with regards to system controls.
Navigation Intuitive	Navigation was consistent and thus straightforward for all participants. Short navigation paths, clear interface design and easy access to the main menu, were reported as facilitators for intuitive navigation.
Interface Clear	Participants indicated that the interface was clear and that all required information was visible. Screen layouts were non-crowded and thus were reported to assist focus on gameplay. Icons were recognisable, with the exception of the ‘statistics’ icon at the bottom of the main menu screen, which was confused for a ‘volume’ icon by some of the participants.

System Responsiveness	Input recognition was provided via feedback, however system responsiveness was occasionally reported to be slow. There was a known issue with the tapping sensitivity in the third mini-game, which resulted in an occasional feeling of feedback not being provided on appropriate time. Since the issue was however noticeable in one of the mini-games, the overall perception on responsiveness remained positive.
Visuals Appropriate	Visual representations and user interface (UI) elements were recognisable by all participants, even those who did not play games on their mobile devices. The general consensus amongst participants was that irrespective of personal taste, visuals were uncluttered, non-distracting and fit for purpose. A small number of participants indicated they would prefer a larger font to allow for more comfortable reading.
Consistency	Consistency was overall reported from participants. Screen layouts and visual style were felt to be consistent between mini-games. Furthermore, the consistency of core functionality was recognised and reported by participants and was indicated by some to have helped intuitiveness and ease of use.
System Learnability	Intuitiveness and ease of use assisted learnability. All of the participants were able to comfortably interact with the system after a short period of time, even though the majority did not use the help functionality or read the instructions.

Table 8-8: Think-aloud themed findings

Findings from the think-aloud with regards to the functionality and interface design of *Lexis* were encouraging and supported the results of the quantitative study. Participants found the game to be usable and reported an overall positive user experience. Some of the participants appeared to be more engaged in playing *Lexis* than others, however all of the participants reported that the system was easy to use. Three areas of future improvement were suggested regarding functionality and the play experience. First, the responsiveness of the system, especially for the third mini-game, was occasionally reported as being slow. As previously mentioned this was a known issue that due to time limitations and the lack of technical expertise was not

fixed for the final version of the game. Second, a number of participants reported initial doubt about the number of words per set for the second mini-game. Since words fell one by one, participants did not initially realise that they had four possible words as options to choose from for to fill the phrase gap. It was therefore suggested that all words should fall at the same time, to allow the player to see all the possible options and to select the most appropriate one. Two of the participants also suggested that it would be useful to have the option to ‘get rid’ of wrong words by swiping them downwards, instead of waiting for them to fall on their own. Finally, the last improvement suggested was to increase the pool of academic words, to avoid repetition of sets. This is logical, since as discussed in Chapter 6 (Designing Mobile Game-Based Learning), the vocabulary used for the game prototype was Group 1 of the Academic Word List (AWL), including the sixty most common academic words encountered. By definition therefore, since the amount of words was relatively small, some repetition of sets was expected when using the system for a continuous period of time, which was the case for the qualitative evaluation.

Summarising the findings gathered during the think-aloud, it could be argued that aside from the three improvements suggested, the game was easy to pick up and play. Participants’ actions and reactions during play testing revealed that the game was quick to start and easy to use, even for those who did not used to play games on their mobile devices. Furthermore, learnability was achieved since all of the participants were able to use *Lexis* and understood how to play all mini-games within a short interaction time, usually without the need for instructions. Finally, since the game fostered initial success via adaptability and short reward cycles, it facilitated a feeling of confidence when using the system, usually within a short time after initial interaction.

8.3.2 Time on Task

Having conducted the first play test and the think aloud, participants were then asked to play the game one more time to conduct a time on task experiment. Gathering data over the time participants spent voluntarily playing the game, was considered as an additional indication of engagement. Voluntary time on task is one of the most common methods employed to measure engagement in educational settings (Virvou et al., 2004). Furthermore, since participants had already been introduced to the game and conducted a play test, it was considered that any additional time spent on the application due to increased interest from first time interaction, would be eliminated. Additionally, during the second play test participants had already become familiarised with the game, the controls and the objectives by conducting the think aloud, so time spent playing did not reflect any getting used to the system. Finally, asking participants to play the game for a second time in order to conduct the experiment, after they had already conducted a playtest for the think aloud, was an attempt to minimise any ‘compliance’ aspect of a possibly conscientious participant, although such a possibility should be acknowledged.

Data gathered from the experiment are presented in the following table. Total time spent on *Lexis* along with time spent on each mini-game was monitored for each participant. Additionally, the time each of the participants returned to replay each mini-game, along with the most time spent on a given mini-game were also recorded.

User	Total Time:	Total Time on:			Times Played:			Most Time Spent on:
		<i>Mini-Game 1</i>	<i>Mini-Game 2</i>	<i>Mini-Game 3</i>	<i>Mini-Game 1</i>	<i>Mini-Game 2</i>	<i>Mini-Game 3</i>	
1	9m 04s	2m 37s	2m 86s	2m 27s	1	1	1	Mini-game 2
2	6m 46s	2m 98s	1m 47s	1m 37s	1	1	1	Mini-game 1
3	8m 42s	1m 67s	4m 57s	1m 28s	1	1	1	Mini-game 2
4	4m 72s	1m 25s	1m 10s	0m 97s	1	2	1	Mini-game 1

5	12m 29s	4m 49s	4m 25s	2m 08s	1	1	1	Mini-game 1
6	3m 52s	1m 87s	0m 98s	0m 43s	1	1	1	Mini-game 1
7	19m 27s	6m 13s	7m 96s	4m 67s	1	2	1	Mini-game 2
8	8m 91s	3m 01s	2m 11s	2m 99s	1	1	1	Mini-game 1
9	10m 56s	-	2m 58s	8m 13s	0	2	1	Mini-game 3
10	10m 40s	4m 2s	1m 29s	3m 24s	2	1	1	Mini-game 1
11	3m 08s	0m 24s	1m 58s	0m 98s	1	2	1	Mini-game 2
12	6m 04s	1m 02s	1m 57s	2m 52s	1	2	2	Mini-game 3
13	7m 02s	2m 6s	2m 02s	2m 11s	1	1	1	Mini-game 3
14	4m 02s	1m 07s	0m 88s	0m 39s	1	1	1	Mini-game 1
15	5m 24s	1m 99s	1m 19s	1m 80s	1	1	1	Mini-game 1
16	5m 08s	2m 34s	-	2m 58s	1	0	1	Mini-game 3
17	4m 36s	0m 49s	1m 16s	2m 07s	1	1	1	Mini-game 3
18	8m 39s	1m 66s	2m 98s	3m 18s	1	1	1	Mini-game 3
19	5m 14s	0m 46s	2m 17s	1m 27s	1	1	1	Mini-game 2
20	13m 40s	2m 41s	5m 45s	4m 83s	1	1	1	Mini-game 2
	Average Time:	Average Time on:						Most Popular Game:
		<i>Mini-Game 1</i>	<i>Mini-Game 2</i>	<i>Mini-Game 3</i>				
— —	7m 8s	2m 1s	2m 4s	2m 5s	— —	— —	— —	Mini-game 1

Table 8-9: Times and play-sessions recorded during time-on-task

To provide a baseline measure to track engagement, the average time spent on mobile applications had to be identified and was found to range between 4 and 8 minutes (Mosaic, 2013), while the average mobile play session was found to last for 2 minutes and 37 seconds (Tack, 2013). Time spent on *Lexis* therefore seems to suggest engagement. The average time spent on *Lexis* was 7 minutes and 8 seconds,

which fell into the upper level of the average time spent on an application. Furthermore, looking at the individual times for each participant, only two engaged with *Lexis* for less than the lower average of 4 minutes. At the same time, the average play sessions for the three mini-games were 2 minutes and 1 second, 2 minutes and 4 seconds and 2 minutes and 5 seconds respectively. Though these were slightly below the average of 2 minutes and 37 seconds, they were still very close. Finally, mini-game one appeared to be the most popular amongst participants, with the most time spent on it on average. This supports the results of the quantitative evaluation according to which mini-game one was indicated as the most engaging among the three, with an average positive response rate of 92%. Mini-game two however, which was the least popular in terms of time spent on it, was the one participants seemed to return to the most. Taking into account the results from the quantitative evaluation according to which mini-game two was found to be the least engaging with a positive response rate of 68%, this might indicate that participants returned for another attempt to the game they found most challenging, but since it was challenging they did not engage for long.

8.3.3 Interviews

After the participants had conducted the time on task experiment, they were asked to undertake a short interview. Interviews are commonly used in qualitative inquiry and generally involve a one-to-one discussion between the participant and the interviewer (Creswell, 1998). Most often, the interviewer asks the participant questions on a given topic, based on a predetermined script. In the case of this qualitative evaluation session however, a semi-structured interview approach was adopted (Bryman, 2004) according to which the researcher asked predetermined questions based on an outline, not at the same time excluding the possibility to venture off the interview script if an interesting direction occurred during the discussion. The aim of the interview was the collection of more in-depth data on participants' perceptions and attitudes. The questions used for the interview are provided in the following table:

Interview Questions
Do you play games on your mobile device? Why/Why not?
Do you think that using the game for a longer period of time would help you build your vocabulary skills? Why/Why not?
Was the activity you undertook engaging? Why/Why not?
Did you feel absorbed in the game, while you played?
Would you use a mobile game for learning? Why/Why not?
Do you think a mobile game is suitable for learning new skills, improving existing ones, both or none?
Do you see yourself using a game like this in your daily life? Why/Why not?
How do you see yourself using a game like this in your daily life?
What would stop you from keep using the game in the long-run?
When you decide to learn a new skill/improve an existing one, do you usually do it independently or through a formal course?
Do you see a mobile learning game being used as a standalone learning tool, or as part of a formal course?
Is flexibility an important criterion for you, when taking up learning?

Table 8-10: Interview questions

Following, themed findings from the interview are presented and discussed. Content analysis was conducted on data collected from the interviews in order to identify patterns and make observations. Extracts of the participants' opinions are provided in relation to each observation. The discussion is divided according to the themes addressed by the interview questions and a similar structure is retained for consistency.

Game Playing Habits

When asked whether they play games on their mobile device, most of the participants indicated that they do. Out of the twenty (20), fifteen (15) responded positively and five (5) responded negatively. Those who said they played games on their mobile device did so in various frequencies, ranging from multiple times per day to once a week, to a few times per month. Out of the fifteen (15) however, only four (4) self-identified as gamers, two of which played games on other platforms as well and two who only played on their mobile device. The primary reason given from most participants for playing mobile games was convenience:

I like the convenience of being able to play on the phone, to play whenever I want to.

Of those who indicated that they did not play games on their mobile device, most had played at some point and then stopped or played very rarely, however only one (1) said they had never played. Overall, the results were consistent with the quantitative data collected and presented in the previous section. Interestingly, no connection between playing habits and attitudes towards learning with a mobile game were observed. Participants who self-identified as mobile gamers, or those who played mobile games often, did not necessarily find the idea of learning with a mobile game more appealing than others. On the contrary, two (2) of the participants who reported playing mobile games were not so positive towards learning with a mobile game. At the same time, those who did not play games on their mobile device were not necessarily negative towards learning with a mobile game. Three (3) participants who indicated that they rarely played and one (1) who reported playing and then stopping, were all positive towards the idea of learning with a mobile game. The only connection between play habits and attitudes towards learning with a mobile game reported was the one (1) participant who indicated they never played mobile games and who was also negative towards the idea of using them for learning. The results of the interviews align with those of the background study described in Chapter 4 (Background Study), where many of the participants who reported not playing mobile games were still positive towards the idea of using them for learning.

Game Value

Encouraging was the fact that all of the participants responded positively when asked whether they believed that using the game for a longer period of time would help them build their vocabulary. The fact that participants thought the game was helping them to learn was also reflected in the quantitative results, according to which 100% responded positively regarding the learning value or *Lexis*. One of the participants who was also personally involved in language education responded:

In this day and age I think we learn much easier from games than from the books. I think this is one of the best methods to learn a language, and especially vocabulary.

Furthermore, another participant noted that the applicability of the specific vocabulary was broad and that it could be used not just in academic but also professional settings. This supported the argument made in Chapter 6 (Designing Mobile Game-Based Learning) that English for General Academic Purposes (EGAP) is applicable to both academic and professional settings and thus as learning content it could be appealing to a wider range of adults in comparison to discipline-specific academic vocabulary.

Yes of course the game would help build vocabulary skills. And may I add that the vocabulary of the game can suit different situations, so labelling it as academic is a bit unfair because that high register of speech is needed for all work like situations. So I can see a value overall, I don't think it would only help academic oriented people.

The participants recognised elements of the game design as helpful for language learning, and specifically the fact that words were repeated during gameplay and that they could be used in context. Though participants were not aware of the adaptability of the system, which repeated word sets previously answered in error during gameplay, that was an indication of functionality having a positive effect on the attitudes formed towards the game.

...I mean, I remember playing another game...quiz something.... which was a similar concept, it's a question and answer but more knowledge based and I enjoyed that type of game, so sure I would enjoy something similar. So there is a learning potential there because if you get it wrong, you can see the correct answer and then you'll get the question again at some point later, you'll see if you remember the answer; so given enough time I'm sure you'll learn.

Yes, I think it will help you learn because it's not just about learning new words. It is also about learning how to use them in context. Also, since there is an amount of repetition I think this helps as well.

Finally, there were some participants who although recognised the learning value of the game, they also suggested future improvements regarding the range of vocabulary used.

If the vocabulary with which you could play was very broad, then yes you could improve. And if the words presented were challenging, so way beyond common language, that would definitely help. So it depends on which level of vocabulary you are on.

I definitely think that the game would help me build my academic vocabulary. As long as it offers increased difficulties and increasing levels, definitely it's going to help.

Participants who made such suggestions were amongst the ones with a higher level of English competence and who found the game to be easier in comparison to others. This suggested that though adaptability was build into the game to accommodate a range of language competence, broader level categorisations would be useful to accommodate an even wider array of language skills.

Engagement

Overall participants found the game engaging. Most of them were quite positive about their play experience and commented that they had enjoyed the game. The qualitative data collected aligned with quantitative scores, according to which a clear majority had felt that time passed quickly during play (88%), had enjoyed the activity (92%) and had not found the game to be boring (84%). Positive comments on engagement suggest a positive user experience and are an indication of effective design, according to the guidelines proposed in Chapter 5 (Developing Design Guidelines for mGBL). Some of the comments relevant to the design of the game were:

Though it's a simple game as per the rules and everything, it is really engaging and as they say, the simpler it is the better it is.

It made me want to do well. And while doing well, and you know getting a bonus life... like... being appraised for doing well, I wanted to keep on-going.

Yes I did find it engaging! I wanted to keep playing.

I liked it because I had three mini-game options, so I could switch if I got bored with one. And even though the concept was the same, like learning words and things like that, the way they were delivered was completely different.

On the other hand, although negative comments on the user experience were uncommon, there was an interesting response from one of the participants who self-identified as a gamer and reported playing games often. Input in this case indicated a preference not directly linked with the specific design, rather than towards the type of platform and setup.

Hmm...I wouldn't say I was absorbed. Well, to be fair, although I play games on my mobile I rarely find myself absorbed in the game. I mean, I enjoy doing it but it's more like something to help me kill time. If I want to play something and be absorbed it will usually be on a large system, usually...big screen.

Quite interesting was also the fact that the learning aspect of the application seemed to engage many of the participants.

I could see why I was playing the game, it helped me with my vocabulary, so I enjoyed having this mission to complete...this purpose...and I could feel I was learning, so in that sense I was engaged.

It felt satisfying testing my knowledge!

It was intellectually engaging yes, and visually I think it was very pleasant.

Because the knowledge element is there, you need to know and understand the word, so you need to be focused and thus you become absorbed.

It also appeared that the concentration required by the learning element of the game, enhanced engagement and in some cases led to absorption. Furthermore, seeing the value of the activity provided a sense of purpose for some, which also assisted engagement.

Acceptability for Learning

One of the most encouraging findings of this research has been the acceptability of mobile games as learning tools by adults. The potential for mobile games for learning was initially observed during the background survey, as described in Chapter 4 (Background Study). According to the survey, 83% of respondents indicated that they would use a mobile game to learn, a percentage that was much higher than expected. The same tendency was observed during the interviews, since seventeen (17) out of the twenty (20) participants responded positively to the question: ‘Would you use a mobile game for learning?’ Some of the positive responses provided can be read below:

I would definitely use a game to learn. Learning while playing I think is the next step to actively being educated. You cannot sit at a desk and wait for the teacher to throw stuff at you and then go back to your place and do your homework. That cannot work for adults anymore, because you don't have the time and energy, you need something that will engage you, absorb you and offer you the information through that experience. We are not meant to have the gurus...the experts and wait for them to teach us, we need to actively seek the knowledge, there is no other way.

Yes I would use a mobile game to learn, because its easy; it's the convenience of having it on your phone. I find it engaging learning through a process of not only having to study, but via playing.

Yes because I found playing the game [*Lexis*] calming. I felt it took the edge off the process of learning.

Another interesting observation was that certain participants already used digital tools and applications to learn and thus found the idea of learning with a mobile application comfortable and familiar. There were a couple of participants who said they had used games for learning before and one who was actively using them for vocabulary learning.

Yes, I am using a lot of web based sites and applications to learn different stuff like programming languages, so definitely a mobile application would be very useful. I have tried to learn Spanish via podcasts on my iPhone, so something similar I guess is trying to learn something through a mobile game. So yeah, I would use it.

I am using games for learning. You always have your phone with you, they usually take less than 3-5 minutes and if you practice everyday I noticed that with vocabulary you improve rapidly, so yeah... I use them quite a lot. And I recommend it to my students [participant previously indicated being involved in language teaching].

Positive was also the fact that even the participants who had not considered mobile games as learning tools before were not negative about the idea of using a game if it would help them learn. The general tendency in that case was to not dismiss or adopt the idea solely because the medium for learning was a game. If a tool was going to help them learn, they would use it.

Yes, why not. I enjoy playing games, so if I could learn from a game, why not.

To be honest I haven't done it yet, ahh...but why not. I think it's interesting. Probably because I haven't actually found something I want to learn and found an application for it. But, I would definitely give it a go.

Finally, there was another observation regarding learning acceptability amongst participants, who found the idea of learning with a game interesting but not applicable to all contexts. In that case, mobile game-based learning was seen as suitable for certain types of learning content, leaning more towards skills development or something 'easier' that did not require much time commitment, in comparison to other tools that were seen as more suitable for learning in greater depth.

Yes and no, I would use it because it's on the phone, but then it depends on the type of learning. If it were something you wanted to devote time on you wouldn't do it on a bus with your phone, so it depends on the learning game I suppose. If it was an easy game like this I would use it, but if it got fairly complicated I would prefer to have it as a standalone software, where I could do it later after work.

Similar observations on the types of outcomes achievable via mobile learning games were made in later questions, and will be described following in this section. Though this shows a tendency to believe that the capabilities of the framework are currently limited, it may be to an extent explained by the fact that the technology is still quite

new and the field is relatively immature, so not a lot of case studies on game-based learning applications exist at the moment which can help with various types of learning. Furthermore, there is an argument to be made that richer learning experiences are currently associated with other types of mobile learning interventions such as context-aware applications. As mobile gaming technology progresses however and the capabilities of modern devices allow for more complex designs, it is argued that case studies on richer learning experiences with mobile games will start to emerge. On the other hand, independent microlearning contexts aimed at skills development based on behaviourist approaches, as is the case of this research can be quite successful in this context and are therefore not negatively affected by this observation, since participants seemed to find this type of learning appropriate for the medium.

Types of Skills

Non-directly following on from the above theme, the next interview question aimed to examine participants' attitudes towards the types of skills appropriate to be enhanced via a mobile learning game. When asked whether a mobile game would be suitable for learning new skills or improving existing ones, fourteen (14) out of the twenty (20) participants replied it would be suitable for both:

Both, it could teach you something completely new or help you develop your skills.

In comparison, the other six (6) participants said that a mobile learning game such as *Lexis* would only be suitable for improving existing skills:

Well...for this type of game, if you don't know the language you won't be able to play, so it really is for advancing skills that you already have, or for reinforcing them. It's not for early language levels.

Some of the participants who indicated that a mobile game could also be used for learning something new however found that this would be for entry-level skills:

Even for something new it would be fine, as long as that subject would be fairly easy to catch up and you could do many short sessions, because if you are using a mobile phone it means you don't have your full concentration on it because you are in an environment and at that time your phone might ring, or you get a text; so it would be ok for new things as long as you could stop and pick up where you left off. So having smaller sections of learning and not very deep learning on the subject. So you could have a mobile phone for some 'surface learning' and then go to your laptop and do more study I suppose.

If you want to learn a language you could do it with a mobile phone, sure; but that would be your starting point, you would start with something like this and if you like the language and you think you are picking up the words then you would switch to a formal tutorial, or an online course or something like that. But I think the mobile game would be the entry point.

The above observations link to that made in the previous question, according to which some of the participants found mobile learning games suitable for specific contexts, relevant to skill development rather than in-depth learning.

Context of Use

The next two interview questions asked participants about their perceptions of the context of the use of a mobile learning game. The first asked whether they would use such a game in their daily life. Responses were positive with eighteen (18) out of the twenty (20) participants saying they would, although some noted that they may not use it daily, but they would still play occasionally. Only two (2) of the participants responded negatively and said that they would not see themselves using a mobile learning game. Then, participants were asked how they would see themselves using the game, meaning what would be their projected patterns of usage in terms of time, place and frequency. The consensus was during transportation and downtimes for short and frequent play sessions:

I would probably play during my lunch break, or my way back home. In times when I wanted something more than just checking news and things like that.

It would be a good idea to passing productive time when you are on a break from something else. At home, in the library....

I would say very regular short play sessions, more like a break from something boring just because it's fun and engaging. So maybe at a coffee break or a lunch break at work, but other than that you know...when I commute on the bus or maybe even when I'm at home and want to do something that's useful but not too forced.

On the tube! Because I live in London and it takes about 30min to go to the centre so all this time I can play; on transportation in general. And also at home, when relaxing.

One participant however indicated that the frequency of play would depend on language competence:

If it was for a new language I don't already know I would use it more often. But for a language I already speak and know, I would use it not as often.

Long-term Engagement

Interestingly enough, when asked about possible reasons for stopping using the game after a period of time, all participants provided the same answer in different wording variations. The reason for not using the game in the long run would be repetitiveness of content. Some of the responses provided can be seen below:

The only thing I see stopping me from playing a game like this would be if I reached the end level. So, if I am getting the same words I know already, so I have beaten the game in a sense.

Repetition of questions...as soon as you master the content. I don't think it would be the gameplay that would get boring it would be the same content. So it would need a continuous renewal of content.

If I reach a point I get bored with the game I might replace it with something else. Though most games nowadays have updates and stuff, so they have new quests. If there are new quests I don't think I would get really easily bored.

Most participants responding to this question commented that they would expect frequent updates regarding the content of the game, which would keep them engaged by allowing them to interact with vocabulary they did not already know.

Formal or Informal Approach to Learning

Since the study was targeted towards adult learners, another attitude to be monitored was preference and perceptions towards formal and informal learning. Participants were asked whether they would prefer to learn independently or via a course and the answers varied. Half of the participants responded that they would prefer to learn independently:

Now that I am getting a bit older, I think how you educate yourself is more about your own pace instead of being forced to go to a course for six months or three months. So I think independent learning is better as long as you have the discipline to stick to it. Otherwise you need someone else to enforce it to you, which is not the best. So I think the best option is to go individually and start learning and to go at your own pace.

I only do it independently nowadays. I think formal courses are more for a different stage of life, back when we were students I guess. Now with so many commitments at work and life, it's always better to be more flexible and do it on your own time. Plus to be honest I think formal courses are not as engaging.

Well I wouldn't go to a course if I could do it on my own. Depending on what resources I could find online, or in the library or anywhere...it depends. But I have done a lot of similar actions like language learning or getting diplomas on my own instead of going to a school because schools are always more expensive and you need to devote a lot of time, and it's not a very rewarding experience.

Seven (7) of the participants said they would use both methods depending on context and the skill they wanted to develop:

It depends. If it's something I know a bit about already, then I will continue trying to learn it independently. But whenever I am stuck and I realise I can't do any progress by myself then yes I am taking a formal course.

I'll probably just go online and find something that I can learn with, but I might join a course. So if I were to learn something from scratch for which I had very limited skill, I would maybe join a course. It depends on the thing you want to learn and the stage you are at. If you are a complete beginner you probably need someone to introduce you to it, and then you can keep on learning on your own.

Me I often use something in-between, I mean I have used online course which are formal and informal at the same time, cause you don't have a teacher in front of you and you actually learn on your own but with a bit of help and feedback.

Only three (3) out of the total twenty (20) participants asked indicated they would prefer to learn via a course:

I always try the formal part first...yeah, a formal course would give me the security of someone telling me what to do and if I am doing the correct thing.

The responses indicate that the hypotheses made in Chapter 2 (Literature Review) with regards to the potential of informal, personalised learning solutions for adults, under the assumption that they often take up independent learning projects, could be supported. Without excluding formal education therefore, there seems to be an argument in favour of learning tools addressing the needs of adults in their independent learning.

Standalone VS Blended

Participants were asked about possible ways to integrate a mobile game into learning. The aim was to make observations on whether a mobile learning game like *Lexis* was seen as a standalone learning tool or as a complementary activity to an organised course. The majority of participants responded that they saw the game as part of a course:

I think it would be great as a supplementary tool. Especially if the teacher or whoever provides the original course endorses it and makes you want to play it and gives you some goals to achieve. As a standalone, you definitely need some kind of background. I mean, you can't start from nothing and then suddenly start a game... I mean, that's what I think.

Well I think people trying to learn something new, they can't just be using one tool, they need to be using all the opportunities they have around them to go where they need to go. So you need other resources to make your knowledge complete.

I think it would be complementary, although having said that if the game included many other aspects of learning a language not just reflected on the

screen, like audio input...maybe. I mean you could make a very complex game where you introduce audio-visuals and so on. Interestingly enough, one of the participants perceived the game as complementary to a course, not in terms of content but in terms of design detail, suggesting that a standalone tool should feature a richer visual environment:

As the game is right now I think it's more for complementing a course, because the purpose is to learn not to attract so much the eye. But if it has a purpose to be a standalone game the interface should be more colourful or more interactive...with more detail.

A couple of participants also reported potential to use the game in both situations. Either as complementary or as standalone:

It works in both situations really. Part of a formal course is probably more interesting because it's giving life to theory, so it works very well with that. As for a standalone learning tool, yeah definitely.

Finally, a smaller number indicated that the game was suitable as a standalone tool:

I see it more as a standalone learning tool because of the flexibility it offers. It could be great if it could be used as part of a formal course but that would take the word 'formal' out of context. So I guess it is more like something that you can use to learn things on your own time and speed. Formal courses are less engaging and less fun and very difficult to follow due to work limitations.

Need for Flexibility

The final observation made during the interviews was the need for flexibility when taking up learning. Linking to a previous question on formal and informal learning preferences, it was considered important to evaluate whether flexibility was a key criterion for adult learners. Following on from the background survey (Chapter 4), where survey respondents indicated flexibility as the most important criterion for learning, the majority of interview participants highlighted the importance of flexibility as well. Thirteen (13) out of the twenty (20) responded that flexibility was important for them, while four (4) said they wouldn't mind and two (2) said that it wasn't important. The importance placed by both the respondents of the background

survey and the participants of the qualitative evaluation on flexibility, is encouraging in supporting the hypothesis that flexible learning is key to engaging adults and thus more tools for anytime and anywhere learning should be offered.

We are adults, we are not kids anymore, our main job is not being in school and learning, so you have your actual life and your job and you have to place your education somewhere in there, and that's what flexibility is there for.

Yes being able to access the learning tools wherever I am, is important because I have such limited time. So either online learning or yeah... using applications that you download and you can engage with when you want.

Yes I think it's the most important criterion, being flexible, because...oh well, we are working eight hours, then we have our life, so I guess you know...it's better if when someone wants to learn something that they decide when to learn it instead of having a 4-6pm language course that probably wouldn't be fun to start with.

The overall findings from the interviews have been encouraging and reveal potential for the mobile game-based learning framework proposed through this research. Both the quantitative and qualitative evaluations of *Lexis* suggested that the game was engaging and usable, while participants recognised learning value in the activity. Furthermore, the qualitative evaluation allowed the investigation of participants' immediate reactions to, and interpretations of the game, as well as their attitudes towards mobile learning games more broadly.

8.4 Indications of Learning

As discussed previously in this chapter, direct learning was not evaluated and a case was made for evaluating engagement and usability instead, in order to assess the effectiveness of a mobile game-based learning application (see section 8.1 Evaluating *Lexis*). It was however felt important to attempt to identify possible indications or learning that could emerge via the examination of the data collected in various stages of the above evaluation sessions. If identified, such indications could support the potential of the framework and make a stronger case regarding the effectiveness of *Lexis* for language learning.

During play testing, evaluation participants were asked to play the game freely for as long as they felt engaged to, while the screen of the testing device was recorded. These recorded play testing sessions provided the opportunity to review in-game interactions for each participant and draw some initial conclusions on possible indications that learning took place during the time participants spent playing *Lexis*. The performance of each participant in the game was monitored to see whether words encountered were correctly or wrongly identified and used in each mini-game. The aim was firstly to observe whether words were overall correctly or wrongly identified and used upon first encounter, which would provide an indication of the initial competence level of each participant and the general difficulty of the game. Secondly, to examine whether words that were wrongly identified and used upon first encounter would then be correctly identified on a later encounter, which would provide an indication that the participant had learned them through repetition during gameplay. Since the vocabulary used for *Lexis* was the 60 most common academic words according to Coxhead's (2000) Academic World List (AWL), the pool of encountered words was relatively small and so there was a probability that previously wrongly identified words would be repeated during a game session. An element of randomisation needs to however be acknowledged here, since words that were wrongly identified and used during gameplay did not necessarily reappear in all instances.

It is also important to clarify that the data used to investigate possible indicators of learning, were those of the participants who conducted the quantitative evaluation. This is because for the thirty (30) participants who completed the quantitative evaluation the screen of the device was recorded during the first (and only) play testing session (see section 8.2 The Quantitative Evaluation). On the contrary, the twenty (20) participants who conducted the additional activities of the qualitative evaluation, play-tested the game twice. The first time, they were asked to conduct think-aloud while playing and their voices were recorded instead of the screen of the testing device (see section 8.3 The Qualitative Evaluation). Then, they were asked to play the game for a second time for as long as they felt engaged, to conduct the time on task experiment and this is when the screen of the device was recorded. For the

purpose of this investigation therefore, the data collected from those participants who conducted the qualitative evaluation were not useful, since they had already play tested the game once before and thus the argument that they had already familiarised themselves with the vocabulary could be made. It was thus decided to only review the thirty (30) screen recordings collected during the quantitative evaluation sessions, since at that instance participants were playing the game for the first time.

Data collected from this review can be seen on the following tables. Each table represents the data corresponding to one participant's play testing session. Initially, the correct answers provided the first time the participant encountered a word during gameplay, are counted. Then, the wrong answers provided the first time the participant encountered a word during gameplay, are counted. Next, the times a wrongly answered word was repeated during gameplay are presented. Since words were randomly generated they could be repeated once, more than once or not at all during a play session. The specific words among those answered wrongly on first encounter that were repeated during gameplay, were noted and are presented next on the tables. Finally, the performance of the participant was monitored for the 2nd, 3rd and/or 4th encounter with each of these specific words. The focus was to examine whether the correct answer was provided on a subsequent encounter with a previously wrongly answered word. Finally, the percentages for correct on first encounter, total correct and total wrong answers are provided for each participant.

	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 1	14	4	0	-			

Correct (First Encounter): 78%	Total Correct: 78%	Total Wrong: 22%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 2	40	8	2	<i>Area</i>	Correct	N/A	N/A
				<i>Indicate</i>	Wrong	Correct	N/A

Correct (First Encounter): 78%	Total Correct: 82%	Total Wrong: 18%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 3	36	12	4	<i>Area</i>	Wrong	Correct	Correct
				<i>Occur</i>	Correct	Correct	Correct
				<i>Export</i>	Correct	N/A	N/A
				<i>Concept</i>	Correct	N/A	N/A

Correct (First Encounter): 64%	Total Correct: 77%	Total Wrong: 23%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 4	38	8	1	<i>Financial</i>	Correct	N/A	N/A

Correct (First Encounter): 81%	Total Correct: 83%	Total Wrong: 17%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 5	74	19	3	<i>Interpretation</i>	Correct	N/A	N/A
				<i>Assume</i>	Correct	N/A	N/A
				<i>Financial</i>	Correct	N/A	N/A

Correct (First Encounter): 77%	Total Correct: 80%	Total Wrong: 20%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 6	36	11	4	<i>Area</i>	Correct	N/A	N/A
				<i>Indicate</i>	Correct	N/A	N/A
				<i>Occur</i>	Correct	N/A	N/A

Correct (First Encounter): 72%	Total Correct: 78%	Total Wrong: 22%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 7	79	20	3	<i>Factors</i>	Correct	N/A	N/A
				<i>Area</i>	Correct	N/A	N/A
				<i>Percent</i>	Correct	N/A	N/A

Correct (First Encounter): 77%	Total Correct: 80%	Total Wrong: 20%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 8	49	28	10	<i>Authority</i>	Correct	Correct	N/A
				<i>Area</i>	Wrong	Correct	Correct
				<i>Assume</i>	Wrong	N/A	N/A
				<i>Identified</i>	Correct	N/A	N/A
				<i>Response</i>	Correct	N/A	N/A
				<i>Definition</i>	Correct	N/A	N/A
				<i>Financial</i>	Correct	N/A	N/A
				<i>Major</i>	Correct	N/A	N/A
				<i>Function</i>	Wrong	N/A	N/A
				<i>Contract</i>	Correct	N/A	N/A

Correct (First Encounter): 54%	Total Correct: 66%	Total Wrong: 34%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 9	31	1	0				

Correct (First Encounter): 97%	Total Correct: 97%	Total Wrong: 3%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 10	87	14	4	<i>Involved</i>	Wrong	N/A	N/A
				<i>Create</i>	Correct	Correct	N/A
				<i>Consistent</i>	Correct	N/A	N/A
				<i>Data</i>	Correct	N/A	N/A

Correct (First Encounter): 82%	Total Correct: 86%	Total Wrong: 14%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 11	27	11	2	<i>Authority</i>	Wrong	Correct	N/A
				<i>Benefit</i>	Correct	N/A	N/A

Correct (First Encounter): 66%	Total Correct: 71%	Total Wrong: 29%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 12	51	11	2	<i>Response</i>	Correct	N/A	N/A
				<i>Benefit</i>	Correct	N/A	N/A

Correct (First Encounter): 80%	Total Correct: 83%	Total Wrong: 17%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 13	15	7	0				

Correct (First Encounter): 68%	Total Correct: 68%	Total Wrong: 32%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 14	65	16	2	<i>Area</i>	Wrong	N/A	N/A
				<i>Indicate</i>	Wrong	N/A	N/A

Correct (First Encounter): 78%	Total Correct: 78%	Total Wrong: 22%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 15	69	26	10	<i>Established</i>	Correct	N/A	N/A
				<i>Area</i>	Wrong	Correct	Correct
				<i>Concept</i>	Correct	N/A	N/A
				<i>Role</i>	Wrong	Correct	Correct
				<i>Method</i>	Wrong	N/A	N/A
				<i>Export</i>	Correct	N/A	N/A
				<i>Benefit</i>	Correct	N/A	N/A
				<i>Individual</i>	Correct	N/A	N/A
				<i>Data</i>	Correct	N/A	N/A
				<i>Occur</i>	Correct	N/A	N/A

Correct (First Encounter): 63%	Total Correct: 73%	Total Wrong: 27%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 16	25	13	1	<i>Create</i>	Correct	N/A	N/A

Correct (First Encounter): 64%	Total Correct: 67%	Total Wrong: 33%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 17	53	14	4	<i>Interpretation</i>	Correct	N/A	N/A
				<i>Data</i>	Correct	N/A	N/A
				<i>Area</i>	Wrong	N/A	N/A
				<i>Specific</i>	Correct	N/A	N/A

Correct (First Encounter): 75%	Total Correct: 79%	Total Wrong: 21%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 18	71	16	3	<i>Distribution</i>	Correct	Correct	N/A
				<i>Sector</i>	Correct	N/A	N/A
				<i>Data</i>	Correct	N/A	N/A

Correct (First Encounter): 78%	Total Correct: 82%	Total Wrong: 18%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 19	56	11	4	<i>Area</i>	Correct	N/A	N/A
				<i>Method</i>	Wrong	N/A	N/A
				<i>Identified</i>	Wrong	N/A	N/A
				<i>Response</i>	Correct	N/A	N/A

Correct (First Encounter): 79%	Total Correct: 82%	Total Wrong: 18%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 20	47	17	4	<i>Involved</i>	Wrong	N/A	N/A
				<i>Area</i>	Correct	N/A	N/A
				<i>Economic</i>	Correct	N/A	N/A
				<i>Response</i>	Correct	N/A	N/A

Correct (First Encounter): 69%	Total Correct: 74%	Total Wrong: 26%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 21	16	6	1	<i>Area</i>	Correct	N/A	N/A

Correct (First Encounter): 70%	Total Correct: 74%	Total Wrong: 26%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 22	24	6	2	<i>Function</i>	Correct	N/A	N/A
				<i>Data</i>	Correct	N/A	N/A

Correct (First Encounter): 75%	Total Correct: 81%	Total Wrong: 19%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 23	17	9	0				

Correct (First Encounter): 65%	Total Correct: 65%	Total Wrong: 35%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 24	26	13	7	<i>Data</i>	Correct	N/A	N/A
				<i>Authority</i>	Correct	N/A	N/A
				<i>Role</i>	Correct	N/A	N/A
				<i>Approach</i>	Correct	N/A	N/A
				<i>Financial</i>	Correct	N/A	N/A
				<i>Area</i>	Wrong	N/A	N/A
				<i>Definition</i>	Correct	Correct	N/A

Correct (First Encounter): 55%	Total Correct: 70%	Total Wrong: 30%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 25	53	14	3	<i>Economic</i>	Correct	N/A	N/A
				<i>Contract</i>	Correct	N/A	N/A
				<i>Function</i>	Correct	N/A	N/A

Correct (First Encounter): 76%	Total Correct: 80%	Total Wrong: 20%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 26	16	17	5	<i>Area</i>	Correct	N/A	N/A
				<i>Benefit</i>	Correct	N/A	N/A
				<i>Function</i>	Wrong	N/A	N/A
				<i>Authority</i>	Correct	N/A	N/A
				<i>Indicate</i>	Wrong	N/A	N/A

Correct (First Encounter): 42%	Total Correct: 50%	Total Wrong: 50%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 27	22	7	1	<i>Area</i>	Wrong	Wrong	Correct

Correct (First Encounter): 69%	Total Correct: 72%	Total Wrong: 28%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 28	13	12	1	<i>Estimate</i>	Correct	N/A	N/A

Correct (First Encounter): 50%	Total Correct: 54%	Total Wrong: 46%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 29	37	11	3	<i>Authority</i>	Correct	Correct	N/A
				<i>Variable</i>	Correct	N/A	N/A
				<i>Method</i>	Correct	Correct	N/A

Correct (First Encounter): 66%	Total Correct: 80%	Total Wrong: 20%
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	Correct Answers (First Encounter)	Wrong Answers (First Encounter)	Wrong Answers Repeated	Words Repeated	2 nd Encounter	3 rd Encounter	4 th Encounter
Participant 30	44	9	1	<i>Authority</i>	Correct	N/A	N/A

Correct (First Encounter): 81%	Total Correct: 83%	Total Wrong: 17%
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AVERAGE	Correct (First Encounter): 71%	Total Correct: 76%	Total Wrong: 17%
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Looking at the data collected and presented above, there are some conclusions to be drawn regarding *Lexis*. Firstly, the game appears to be relatively easy for the majority, since the average percentage of correct answers upon first encounter across all participants was 71%. Moreover, the average percentage of total correct answers across all participants was 76%. 60% of participants achieved a percentage of total correct answers above the average of 76%, by comparison to the remaining 40% who achieved a percentage below it. It appears therefore that 60% of participants found the game easy, while 40% found it more challenging. It is worth noting however that the participants who were recruited for this study were on average better skilled than the population. This is because they were primarily recruited via calls for participations within the schools of Edinburgh University and therefore represented a mixed group of postgraduate students, researchers and highly skilled professionals who self-identified their level of English competence as intermediate to advanced. It was therefore anticipated that they as a group, would find the game easier in comparison to other groups. This conclusion however supports the need for further evaluations of *Lexis* with different populations and for monitoring levels of language competence as suggested in Chapter 9 (9.3 Future Work), as well as the implementation of semantic distance adaptability to make the game more challenging to advanced players (see section 7.3 Future Development). Finally, the adaptability algorithm of the system could be redesigned for a future version of *Lexis*, to increase the probability of representing the words which the learner got wrong.

A very positive conclusion that came out from the investigation was that 57% of participants completed the game with all initially wrong answers correct. This means that an initially wrongly answered word was then correctly answered on a subsequent encounter (2nd onwards), after feedback had been provided by the game. When a word had been correctly answered, none of the participants went back to answering wrongly again, which could be an initial indication of learning. Another indication of learning while playing is the fact that the average percentage of correct answers upon first encounter (71%) and total correct answers when the game was completed (76%) increased by 5%. This is an observable performance increase during a single play session.

Although such indications do not provide evidence of learning, which would need to be verified via further research, results therefore appear to be positive to suggest that learning through repetition has taken place in the game.

8.5 Discussion

As described in section 1.3 (Research Questions and Aims), the primary hypothesis of this research was that mobile games have the potential to become effective learning environments that are able to support adults developing their skills independently. The evaluation of *Lexis*, as described previously in this chapter, provided preliminary data in support of this hypothesis.

Initially, the results of the quantitative evaluation indicated that participants perceived *Lexis* as both engaging and usable, which according to the discussion in section 8.1.1 (Evaluation of mGBL) was perceived as an indication of learning from the game. According to the results of the Likert scale questionnaire, the majority of participants found it easy to get started (84%), wanted to complete the activity (94%) and felt that time passed quickly while they played (88%). Encouraging was the fact that 82% of the evaluation participants indicated that it was clear to them what they could learn from the game, while they found value in the activity; since 100% said they had not found the activity to be pointless. The results of the usability related questions were equally encouraging, since participants had found the system easy to use (76%) and the controls intuitive (88%), while with regards to the interface, the majority found that the visual design between mini-games was consistent (96%). As anticipated, a known issue with the sensitivity of tapping input in the testing device had an affect on questions regarding the responsiveness of the system, though positive responses still made up the overarching percentage.

Data collected regarding engagement and user experience support the positive impact of the developed design guidelines for mobile-game based learning applications (presented in section 5.3 Guidelines for Designing Mobile Learning Games). It is therefore argued that these design guidelines could guide the future development of effective and engaging mobile learning games. Since *Lexis* represents the first practical application of the guidelines however, the development of further prototypes is required. Optimal implementations of the guidelines are expected to yield effective mobile games for the independent learning of adults.

The quantitative evaluation however gave no insight into the post experiential perceptions of participants or their attitudes towards mobile game-based learning. It was therefore decided to conduct a qualitative evaluation as well, to investigate their immediate reactions to and thoughts about *Lexis*. The findings indicated participants' positive tendency towards using mobile games for learning. Positive was also the fact that consistency was reported between the findings of the final evaluation and those of the initial research conducted, as described in Chapter 4 (Background Study), which further supports the original hypothesis on the potential of mobile game-based learning for adults.

Summarising the interview findings, all of the participants found learning value in the game and responded that they believed it would help them build their academic vocabulary if used for a longer period of time. A larger pool of words was suggested as a future improvement to assist learning from the game. Some of the participants said that they found themselves absorbed while they played and that the concentration required due to the learning element of the gameplay, helped them to retain their engagement. Surprisingly when asked about the reasons that would make them stop using the system in the long run, all of the participants responded repetitiveness of content and suggested content updates as a solution. The participants indicated they could see themselves using the game in their daily lives, while only two (2) out of the twenty (20) said that they would not use the game.

One of the most encouraging findings was the level of acceptability of mobile game-based learning amongst participants, since seventeen (17) out of the twenty (20) said they would use a mobile game to learn. No connection was however observed between playing habits and acceptability, since participants who self-identified as mobile gamers did not necessarily find the idea of learning via a mobile game more appealing than others. Overall, participants found that a mobile learning game could be suitable for both learning new skills and for developing existing ones. Some of the participants however found that mobile learning games would be better suited to certain types of learning content, relevant to skill development rather than in-depth knowledge acquisition. Independent microlearning contexts aiming at skill development based on a behaviourist approach, as is the case of the framework proposed in this research, could be successful in this context. Finally, the responses indicate that the hypotheses made in Chapter 2 (Literature Review) with regards to the potential of informal, personalised learning solutions for adults, under the assumption that they often take up independent learning projects, could be supported. Without excluding formal education, there seems to be an argument for learning tools addressing the needs of adults in their independent learning, since most participants when asked indicated that they would prefer to learn independently. Furthermore, flexibility was indicated as the most important criterion for learning.

Two limitations of the study should however be considered. First, the number of evaluation participants was not large enough to allow for a safe generalisation to the population. Taking into consideration the size of the population of adult language learners who are non-native speakers of English between 21-39 years old, a certain number of responses should be achieved for a generalisable statistical sample. For a large unknown population over 1million, a sample of at least 384 responses is required for an acceptable margin of error (see Appendix A). Although for statistical accuracy therefore, 384 responses would have been desirable, obtaining them was not feasible for pragmatic reasons. The number of responses achieved however was considered large enough to indicate emerging trends and to support the general potential of the framework.

The second limitation to be acknowledged was the fact that the long-term effects of the game were not investigated. *Lexis* was designed to be played more than once, since the game architecture and gameplay design were based on the principles of replayable micro-content. The participants involved in the evaluation however played the game once, if conducting a quantitative evaluation, or twice if conducting a qualitative one. As such, their responses reflect single exposure to the game and thus their attitudes and intentions as opposed to solid beliefs.

The next and final chapter of this thesis examines the implications of the findings of this research. The work presented in all the previous chapters is drawn together, discussed and reflected upon, while discoveries, insights and future directions are overviewed.

Chapter 9

Conclusions

In the final chapter of this thesis the work described in the previous chapters is revisited, drawn together and discussed in order to examine the outcomes of the research, to consider what has been learned and to propose future directions for the study.

The first section of this chapter revisits the research contributions introduced in Chapter 1 (Introduction) and discusses the areas of this work that have contributed to knowledge and understanding of the field of mobile game-based learning. The next section moves on to describe the limitations of the work and to critique the areas of the research design which could be improved. Next, future directions for this research are overviewed and proposed. Finally, the last section of this chapter discusses the results and revisits the research questions and the outcomes yielded from research activities conducted to address each of the questions.

9.1 Contributions

The first section of this chapter highlights and discusses the contributions of this research to knowledge in the field of mobile game-based learning. These four contributions have been presented and discussed via research stages, throughout this thesis.

9.1.1 Insight into the Nature of mGBL

The first contribution is a rationale for the use of mobile games in learning situations where adults develop their skills independently, as well as an insight into the application of game-based learning to the mobile context (mGBL). This thesis thus provides an understanding of mobile game-based learning targeted to adult learners.

Furthermore, in this thesis a mobile game-based learning framework where learning happens independently in an informal context and is learner-directed and adaptable to the individual was synthesised. In this context, mobile learning games were positioned on the intersection of the areas of adult learning, game-based learning, mobile applications development and game design. The outcomes of the background study (Chapter 4: Background Study) and the evaluation stages of this research (Chapter 8: Evaluation) described earlier in this thesis revealed that adults in general demonstrate positive attitudes towards learning with a mobile game. However, they will use it if it is perceived as an appropriate way to develop their skills and not solely because it is a game. The flexibility provided by a mobile learning solution, was however perceived as important in fitting learning into everyday life and decreasing barriers to entry. This work however does not claim that mobile game-based learning is suitable to support any type of learning but presents a rationale based on the characteristics of mobile games, casual gameplay, microlearning content and behaviourist learning environments, able to support the independent skills development of adults. Furthermore, the thesis examined the types of games and learning outcomes that might be suitable for the context of mobile game-based learning and provided a framework for discussing mobile game-based learning activities, in an inclusive definition of games provided in Chapter 2 (Literature Review).

9.1.2 A Set of Design Guidelines for mGBL

Apart from contributing to the theory on mobile game-based learning, this research has provided a practical tool for the development and evaluation of mobile learning games. A set of design guidelines to support the development of engaging and usable mobile game-based learning applications was developed. The design guidelines were synthesised based on existing cross-area literature on independent adult learning, game-based learning engagement, mobile usability and mobile game design. Guidelines were also informed by the examination of a number of popular mobile games, from which appealing game and interface design characteristics were extracted.

Four sets of design guidelines were therefore finally presented (Chapter 5: Developing Design Guidelines for mGBL), which aimed at supporting the development of mobile game-based learning for the independent skill development of adults. The first set provided criteria for the effective learning design of a mobile game, based on theory of adult learning in a mobile context. The second set provided criteria for the design of engaging game-based learning activities. The third focused on usability and the ways mobile learning game interfaces could be designed to allow for an efficient user experience. Finally, the last set provided criteria for the design of enjoyable games, fit for purpose for a mobile context. In addition to providing a practical tool to support the development of mobile learning games, the four sets of guidelines can be used as tools to evaluate mobile game-based learning.

9.1.3 A Prototype of mGBL Technology

The third contribution of this research was a working prototype of mobile game-based learning technology, developed based on the above set of design guidelines. The prototype entitled *Lexis*, was targeted at adults looking to develop their vocabulary skills independently. The design of *Lexis* was also informed by the outcomes of a background study conducted as an initial stage of this research to gain insight into the attitudes of adults towards mobile device usage patterns, mobile games and the potential of learning using a mobile game. The purpose of *Lexis* was to help adult second language learners build their English academic vocabulary skills. *Lexis* is a puzzle game based on a mini-level architecture, where each mini-game can support the development of a specific vocabulary skill. The game was developed as a proof of concept and also as an evaluation instrument to examine the effectiveness of the proposed design guidelines for mobile game-based learning. The development process of *Lexis* spanned two iterations of development (Chapter 7: Developing Mobile Game-Based Learning). To address issues in the original design concepts, and to assess the usability and overall effectiveness of the system, an expert review was conducted of the initial game version. The evaluation findings led to design changes that were implemented in the final version of *Lexis*.

9.1.4 An Evaluation of the mGBL Technology

The final contribution of this research is the evaluation of the mobile game-based learning prototype *Lexis*, using both quantitative and qualitative methods to investigate its effectiveness, measure engagement and usability and provide insight into adults' perceptions, attitudes and experiences using the system. Furthermore, the qualitative evaluation specifically allowed for the collection of empirical data on the post-experiential attitudes of adults with regards to mobile games for learning. The outcomes of both the quantitative and qualitative evaluation led to initial support for the research hypothesis on the potential appeal and suitability of mobile learning games to support the skill development of adults learning independently. They also supported the effectiveness of the mobile game-based learning design guidelines, which were developed as the second contribution of this research. The quantitative evaluation involved the collection of mGBL-related perceptions on engagement and usability of fifty (50) participants, after play testing *Lexis*. The qualitative evaluation on the other hand, involved twenty (20) participants performing think aloud, a time-on-task experiment and an interview after play testing *Lexis*. Overall, the evaluation outcomes were encouraging and revealed positive attitudes towards learning with a mobile game. Finally, encouraging was the fact that an initial investigation on learning indications suggested learning via repetition.

In all, the research presented in this thesis makes the above four contributions to the field of mobile game-based learning, providing insight and furthering knowledge in the area as well as synthesising outputs that could be used and applied in future research.

9.2 Limitations of the Study

This section critically discusses the research methods selected and utilised throughout the stages of this study, as well as the issues that arose with regards to the research design and the limitations they led to.

As previously mentioned, this research was targeted at adult learners, which by definition is a broad group and although at certain points during the research stages this target group was brought down to a more specific age range, it still remained quite broad. Thus, although the game prototype *Lexis* was developed with this in mind and was designed to appeal to a wide and diverse range of users, the generalisability of the evaluation findings to the general adult population should be treated with care. Scope therefore exists to run further evaluations with specific adult age groups in future work and to conduct comparative studies in order to determine the extent of the generalisability of the results amongst specific age groups. In terms of this particular research, the age group selected for the evaluation of *Lexis*, was adults between 21-39 years of age. This age range was also the most represented in the online survey conducted for the background study (Chapter 4: Background Study), which examined the mobile phone usage habits of contemporary adults as well as overall openness to the use of mobile games for learning. Although the research outcomes could therefore be relevant to adults in general, the specific age group evaluated was 21-39 year olds.

A limitation reflected in the background study survey (Chapter 4: Background Study), which was one of the initial stages of this research, was the diversity of the population. A wide range of respondents participated in the online survey, leading to responses being collected from various age ranges as well as various geographical locations. The results are therefore considered to be indicative of the population's attitudes towards mobile devices, games and learning. Furthermore, a limitation to be acknowledged is that although geographical constraints were not applied for the survey, the vast majority of respondents came from countries of the western world (96%), and the English-speaking world (64%). At the same time, the three most

represented countries were the United Kingdom, the United States and Greece (total percentage of 77%), which could be predicted based on the existing distributions of the researcher's network of contacts, who were invited to participate.

A further limitation that should be acknowledged is the number of participants for the final evaluation. Fifty (50) participants took part in the quantitative evaluation and twenty (20) in the qualitative evaluation of *Lexis*. Although this number of responses could be considered to constitute a large enough number given the pragmatic limitations of a small scale, time limited research study, caution is suggested in any generalisation of the results to the general adult population. As previously discussed on Chapter 8 (see section 8.5 Discussion) to safely generalise the results to the population, a much higher number of quantitative responses would be required (384 responses for 5% margin of error - see Appendix A); however this could not be secured in this instance. The results can therefore only offer information on tendencies and patterns and to indicate emerging trends. Additionally, it is important to note that evaluation participants were between 21-39 years old and were recruited via calls for participation in Edinburgh University schools and amongst the researcher's professional contacts. Though the selection amongst the responding individuals was random, this recruitment approach may have led to a sample of generally well-educated and technology oriented participants for whom mobile game-based learning might possibly be a more acceptable way to learn. At the same time though there is an argument to be made that this population sample is the one to which mGBL applications for the independent development of skills would be targeted to. Nonetheless, there is scope for future evaluation studies amongst a more diverse population.

Regarding the evaluation of the game prototype, a limitation was that the long-term effects of the game were not investigated. The game prototype *Lexis* was designed to be playable more than once, since the game architecture and gameplay design were based around principles of replayable micro-content. However the participants involved in the evaluation played the game once if conducting a quantitative evaluation or twice if conducting a qualitative one.

Their responses therefore reflect single exposure to the game. Furthermore, responses to the experience were provided immediately after playing, and thus they reflect attitudes and intentions as opposed to solid beliefs. Long-term repeated exposure to the game is however expected to yield stronger post experiential beliefs and potentially lead to learning.

Lexis is a mobile game aimed at assisting English academic vocabulary development, designed for intermediate to advanced users of the language. During the evaluation phase however this variable was not controlled and participants self-identified their level of language competence. This limitation may have influenced participants' perceptions according to their level of language command, however the variable was not controlled for two reasons. First, due to pragmatic limitations of the short time-frame of the research and second since the game prototype was designed to be adaptable to player skill and was therefore considered suitable for a wider range of language learners, in comparison to other digital tools for vocabulary building. Scope therefore exists to either conduct additional evaluations with language learners of various competence levels or to enhance the adaptability of the system and introduce a larger vocabulary pool featuring words addressed to different levels of language learners. However, enhancing the adaptability of the system would require additional development time and technical expertise, as well as the input of language educators to better evaluate the competence level of participating language learners and to advise on suitable word pools addressing each level.

An additional limitation of the evaluation was question wording, which could be addressed in future work by revisiting the wording of certain questions used for the final evaluation questionnaires and interview, which were less successful in eliciting analysable responses. Time permitting therefore, questions that were not previously tested could be reviewed and verified via the use of a pilot study with potential users and subject experts. Finally, it is important to highlight that during the evaluation, direct learning from the game was not measured. For reasons explained in Chapter 8 (Evaluation), engagement and usability were instead monitored as likely predictors of learning.

This approach was supported by the links between levels of engagement with a game and learning from it provided by the literature (Lepper & Malone, 1987; Jacques et al., 1995; Whitton, 2010), as well as arguments supporting the importance of a system's usability for learning effectiveness (Kukulska-Hulme, 2005; Kukulska-Hulme & Shield, 2004). Scope therefore exists to conduct additional experiments over a longer time span and to record learning from the game via the use of pre-/post-test questionnaires. These could then act as direct indicators of the possible enhancement of vocabulary skills yielded from the game, over a set period of time.

9.3 Future Work

The research described in this thesis represents a small number of studies linking to the field of mobile game-based learning and there remains much scope for future work. Here a few ways in which this research could be continued are discussed.

Long-term Evaluation: As previously mentioned, the long-term effects of the game were not investigated during the evaluation stage. It would therefore be interesting to conduct further research to examine the effectiveness of *Lexis* when used repeatedly over a longer time span. The attitudes of players could thus be monitored over a longer period of using the system, possibly yielding different results on player perceptions. This would also allow for an investigation of the longitude effects of the game on the skills of the players and the examination of direct learning from the system. To achieve this, the application should be available to download to the user's personal device instead of using a testing device during an evaluation session. To allow users to freely download the application on their phones however, the game would have to become available via the Apple Store, which for various logistic reasons that had to do with time delays relevant to Apple review processes and additional design and optimising work, was not achieved at the present time. Time permitting however, the game could become available to download via future work and monitoring systems could be build into the system to provide reports on the time and frequency of gameplay over the evaluation period.

An additional benefit of a long-term evaluation would be that conclusions could be drawn on the sustainability of engagement in using *Lexis* over a longer period of time.

Evaluating *Lexis* with different populations: By carrying out larger-scale testing on a wider range of possible users of *Lexis*, it would be possible to begin investigating the effects of different demographics on player perceptions. This would allow the analysis of additional factors on the attitudes towards mobile game-based learning. Specifically, such factors could be age ranges or comparative studies among younger and older adults, gender, ethnicity and level of language competence. Furthermore, comparative studies could be carried out among users with varied familiarity with mobile games to extract solid conclusions on possible links between perceptions towards learning with mobile games and using games for entertainment.

Developing a different game using a similar process: The content of *Lexis* was related to language learning and specifically English vocabulary. However, the design guidelines developed for mobile game-based learning were not specific to a certain topic and could be used to inform the development of mobile learning games able to support different types of skills. An interesting extension would thus be to develop another game, using the same development process and the proposed design guidelines, but focusing on the development of a different skill or a different type of learning content. Assuming the new game would be evaluated using a similar process, the wider generalisability of the effectiveness of the guidelines and the research hypothesis could be investigated.

Extending *Lexis* to support different types of vocabulary: Another interesting direction for future work would be to extend the vocabulary of *Lexis*. As it is, the game can support the development of English academic vocabulary and specifically the 60 most common academic words according to Coxhead's (2000) Academic Word List (AWL). Additionally, the focus is on English for General Academic Purposes (EGAP). It is therefore suggested that the vocabulary could be extended to include both general and discipline specific academic vocabulary. This would allow

for a larger word pool, to avoid the repetition of word sets in gameplay but also to appeal to users interested in building vocabulary skills relevant to specific disciplines, thus allowing for further personalisation. Furthermore, the type of vocabulary could be changed to non-academic. This way the game could be used to support a more diverse range of English language learners. Furthermore, it could be changed to industry specific vocabulary to be used in employee training.

Focusing on collaborative mGBL: The mobile game-based learning framework proposed in this research has focused on individualised learning, while the developed game prototype is a single player puzzle game. The possible effects of collaborative learning have therefore not been examined. Although this tendency was not identified in the results of the background survey or the evaluation results of this study, research suggests that collaboration is important for adults and can lead to engagement (Whitton, 2010; Prensky 2001). Further research could therefore be conducted on collaborative mobile game-based learning, and a multiplayer game prototype could be developed. Additionally, a specific set of design guidelines for collaborative mobile learning games could be synthesised to extend the existing design guidelines for mobile game-based learning.

The above areas of future work proposed are suggestive since there are various other areas of research in the field of mobile game-based learning which could be proposed here. The above five areas however suggest work that directly leads from the work discussed in this thesis.

9.4 Discussion of Results

The first research question considered whether mobile learning games might be appropriate for adults developing their skills independently. From the literature review which was conducted and presented in Chapter 2 (Literature Review), a number of learning theories emerged that supported the use of mobile games as learning environments for adults. This provided a rationale for the use of mobile games, further supported by the outcomes of the background study discussed in Chapter 4 (Background Study), which examined the attitudes of adults towards mobile devices, mobile games and learning. Furthermore, a framework for mobile game-based learning was developed based on theories of mobile learning, casual gameplay and microlearning content, which provided interesting affordances to support independent adult learning and is considered suitable for the context and the target audience.

This study however suggests that when considering mobile game-based learning, the type of learning content and the particular learner, should be examined. Although research supporting the educational and motivational potential of games exists, here it is argued that mobile games can only be effective if designed for learning, supported by a specific learning context and perceived by the learner as a good way to learn. A specific type of game should thus be used in an appropriate environment to support a suitable type of learning. Furthermore, it is not argued that mobile games can replace any other teaching and learning method, but rather that they should be used in situations where they are appropriate and effective.

Overall the results from both the background study survey described in Chapter 4 (Background Study), and the final evaluation with users discussed in Chapter 8 (Evaluation), were encouraging. The participants in both cases indicated a positive attitude towards learning with a mobile game, while even those who were not playing mobile games recreationally did not appear to oppose the idea of learning with a mobile game. However, the outcomes from the interviews of the qualitative evaluation revealed that study participants though positively inclined to use mobile games for learning, would do so if these games were well designed to be usable and

engaging and were perceived as a suitable way to develop skills. It could thus be concluded that adults would not use a mobile game to learn for the sole fact that it is a game, but they would not dismiss it for the same reason either. If however the game was perceived as an effective way to learn and at the same time this learning could be enjoyable, accessible and flexible, fitting around daily life commitments, they would then use it. Finally, there appeared to be no strong evidence linking a participant's willingness to play games for entertainment and willingness to play games for learning.

Furthermore, mobile game-based learning doesn't have to exhibit every characteristic of mobile games aimed at entertainment to be considered enjoyable and playful. Therefore, an inclusive definition of games is provided in Chapter 2 (Literature Review), which can be used to define mobile games for learning. Additionally, the casual values of mobile games as they relate to user experience and gameplay are considered in Chapter 2 (Literature Review), while it is suggested that casual mobile games are appropriate for the context since they can appeal to a wide and diverse range of adult learners.

It was encouraging to find that almost all participants taking part in the final evaluation found the game prototype easy to use and could intuitively navigate, understand objectives and start playing within a short period of experiencing the system. It therefore appears that in terms of accessibility the game was successful, since users with various levels of familiarity with mobile games could "pick up the game and play" (Juul, 2009). This is an argument in support of the effectiveness of the design guidelines informing the development of the game, as described in Chapter 5 (Developing Design Guidelines for mGBL). It could also be argued that gameplay guidelines based on casual mobile game design were appealing to a number of adults, which supports the argument that casual mobile games could be appealing to a diverse audience not necessarily otherwise familiar with games. This is important for learning purposes, since accessibility is key when a learning environment is designed to be used on a wider scale.

The second research question considered the development of good design practices for mobile learning games. Four sets of guidelines relevant to learning design, game-based learning engagement, usability and game design were synthesised and are presented in Chapter 5 (Developing Design Guidelines for mGBL). These were developed based on existing design strategies extracted from the literature as well as gameplay and interface design criteria extracted from the review of popular mobile games. The final four sets of guidelines synthesised can be used to support the design and development of mobile game-based learning and were used to inform the design of the mobile game prototype *Lexis* as described in Chapter 7 (Developing Mobile Game-Based Learning). The design of *Lexis*, as well as the intended learning outcomes of the game is further discussed in Chapter 6 (Designing Mobile Game-Based Learning). Furthermore, the design guidelines can be used as a practical tool to evaluate the effectiveness of a mobile learning game addressing adults developing their skills independently. The evaluation of *Lexis* against the design guidelines supported the argument that they implemented good practices in the design of mobile game-based learning.

The third research question focused on good practices for the evaluation of mobile learning games as described in Chapter 8 (Evaluation). The measurements of engagement and usability were used for the evaluation of the game and were measured instead of direct learning from the system. An initial investigation of indications of learning however returned some positive results that could suggest learning via repletion (see section 8.4 Indications of Learning). A quantitative and a qualitative evaluation was conducted and the outcomes from both evaluations supported the primary hypothesis of this research that mobile games have the potential to become effective learning environments able to support adults developing their skills independently. The results of the quantitative evaluation suggested that *Lexis* was both engaging and usable. The outcomes of the qualitative evaluation conducted with twenty (20) participants revealed that all of the participants found learning value in the game and believed it would help them build their English academic vocabulary if used over a longer period of time. The participants indicated that they could see themselves using the game in their daily lives, while only two (2) out of the twenty (20) said that they would not use the

game. One of the most encouraging findings was the level of acceptability of mobile game-based learning amongst participants, since seventeen (17) out of the twenty (20) said they would use a similar mobile game to learn. Overall, participants found that a mobile learning game could be suitable for both learning new skills and for developing existing ones. Some of the participants however indicated that mobile learning games would be better suited to certain types of learning content, relevant to skill development rather than in-depth knowledge acquisition. Independent microlearning contexts aiming at the development of skills based on a behaviourist approach, as is the case of the framework proposed in this research, could therefore be successful in this context.

Finally, responses indicate that hypotheses made in Chapter 2 (Literature Review) with regards to the potential of informal, personalised learning solutions for adults, under the assumption that they often take up independent learning projects, could be supported. Without excluding formal education, there seems to be an argument in support of learning tools addressing the needs of adults with respect to their independent learning, since most participants when asked said that they would prefer to learn independently. Finally, flexibility was indicated by evaluation participants as the most important criterion for taking up learning.

The research which has been described throughout the chapters of this thesis, aimed to provide insight into the area of mobile game-based learning and the suitability of mobile games as learning environments for the independent learning of adults. Overall, interest in the field of mobile game-based learning addressing adults is growing, while research in the area is considered underdeveloped. It is thus hoped that this work will be utilised as a starting point by other researchers investigating mobile game-based learning as well as designers looking to develop effective, engaging and usable mobile games for learning. It is aspired that the theory and practical tools developed as part of this research will assist future work in the area of mobile game-based learning and support further research in the discipline.

Glossary

Gamer: According to the Oxford Dictionary, a gamer is a person who plays video games or participates in role-playing games. Based on the types of games they play and time and effort they invest in gameplay, gamers can be further classified in hardcore gamers, casual gamers, etc.

Gamification: is the application of game thinking and typical elements of game playing (e.g. point scoring, competition with others, rules of play, etc.) to other areas of activity to encourage engagement with a product or service.

On-boarding: begins when the user first interacts with the game and ends when the user has mastered the fundamental skills required to play and achieve early stage goals. From a design perspective it is about teaching the users the rules to play a game and making their initial interaction with the system comfortable and as intuitive as possible.

Reflex Game: is a type of game, which tests the player's reaction time. Gameplay is often based on the player's reflexive responses, while the game generally retains engagement via quick feedback and gradual addition of difficulty layers. An example could be a puzzle game, which gradually speeds up as the player makes progress.

Appendices

Appendix A

Sample Size Calculation

Following, the sample size calculation for the background study (Chapter 4) is provided. The calculation is based on a very large and diverse population ('Adults aged 18 or over who own a mobile device, have internet access available and are English speaking'). The sample size thus calculated is the minimum number of respondents required for representative results.

There are three factors to consider in the calculation, which will determine the level of accuracy (Rundblad, 2006; Heyman, 2014; Smith, 2013).

Margin of Error (to allow): 5%

Confidence Level: 95% (Zscore: 1.96)

(The most common confidence intervals are 90% confident, 95% confident, and 99% confident).

Standard of Deviation: .5

(This determines variation expected from responses. .5 – this is the most forgiving number and ensures that the sample will be large enough).

Taking the above parameters and values as they apply to the case of the background survey into consideration, the following method can be used to determine the sample size (Smith, 2013):

Necessary Sample Size = $(Z\text{-score})^2 * StdDev * (1 - StdDev) / (\text{margin of error})^2$

Result:

$((1.96)^2 * .5(.5)) / (.05)^2$

$(3.8416 * .25) / .0025$

$.9604 / .0025$

384.16

384 Respondents Needed (*minimum for accuracy*).

It therefore becomes obvious that a minimum number of 384 respondents are required for a representative sample. Here the number has been rounded up to 400 respondents, which was the goal for the background survey discussed in Chapter 4 (Background Study).

Appendix B

Consent Forms

Appendix B.1

Expert Reviewer Consent Form

Research Overview

I am doing a PhD investigating the effectiveness of mobile games as learning tools for adult learners. In the context of the research I am looking to advance a set of design guidelines for the effective design and development of mobile game-based learning. I have developed the alpha version of a mobile iOS game prototype about vocabulary learning, which is designed to appeal to adult learners. Through this review I am interested to investigate the effectiveness of the game, identify possible design issues, reflect on the user interface and overall user experience and gather data that will inform the development of the final version of the game.

Nature of Involvement

I am interested in finding out about your experiences while playing the alpha version of the mobile iOS vocabulary learning game. I would like you to play the game for approximately 40 minutes. During this time I would like you to talk out loud regarding your experience playing the game, your actions, thoughts, attitudes and expectations. During the review I will be seating next to you in silence, taking notes. The think aloud play-testing session will be audio recorded and will last for approximately 60 minutes.

Confidentiality and Anonymity

For the requirements of the research, myself (Thaleia Deniozou - the principal researcher) will be present during the review process. The review will however be conducted in a confidential basis, as access to the research data will be restricted to myself, and my research supervisors. Although opinions and information shared during the review session may be discussed in the final PhD thesis as well as later publications, identities will always be concealed and opinions will remain anonymous.

Consent Declaration

I have been provided with adequate information relating to the nature and objectives of this research project, and have been given the opportunity to ask questions about the research.

I agree to participate as an expert reviewer for the mobile iOS vocabulary learning game, as part of Thaleia Deniozou's PhD research. I understand that the information

I provide by way of expert evaluation, including attitudes, opinions, recollections, and facts will be used only for the purposes of this research project. I also understand that my identity will be concealed in writing up the final thesis as well as any future publications and all information I provide will remain anonymous. Additionally, I am aware that this research may be published in the form of conference posters, papers, and journal papers, as well as in the form of a PhD thesis. I am finally aware that any data obtained as a consequence of my participation (i.e. recordings, transcripts, notes) will be kept safe and destroyed within 3 years of the research conclusion.

Name:

Signature:

Date:

If as a participant you have any questions regarding your involvement in this research, please do not hesitate to contact the principal researcher:

Thaleia Deniozou Principal researcher
Edinburgh College of Art, The University of Edinburgh
tdeniozou@gmail.com

Appendix B.2

Game Tester Consent Form (alpha version)

Research Overview

I am doing a PhD investigating the effectiveness of mobile games as learning tools for adult learners. In the context of the research I am looking to advance a set of design guidelines for the effective design and development of mobile game-based learning. I have developed the alpha version of a mobile iOS game prototype about vocabulary learning, which is designed to appeal to adult learners. Through this review I am interested to investigate the effectiveness of the game, identify possible design issues, reflect on the user interface and overall user experience and gather data that will inform the development of the final version of the game.

Nature of Involvement

I am interested in finding out about your experiences while playing the alpha version of the mobile iOS vocabulary learning game. I would like you to play the game for approximately 40 minutes. During this time I would like you to talk out loud

regarding your experience playing the game, your actions, thoughts, attitudes and expectations. During the review I will be seating next to you in silence, taking notes. The think aloud play-testing session will be audio recorded and will last for approximately 60 minutes.

Confidentiality and Anonymity

For the requirements of the research, myself (Thaleia Deniozou - the principal researcher) will be present during the review process. The review will however be conducted in a confidential basis, as access to the research data will be restricted to myself, and my research supervisors. Although opinions and information shared during the review session may be discussed in the final PhD thesis as well as later publications, identities will always be concealed and opinions will remain anonymous.

Consent Declaration

I have been provided with adequate information relating to the nature and objectives of this research project, and have been given the opportunity to ask questions about the research.

I agree to participate as an expert reviewer for the mobile iOS vocabulary learning game, as part of Thaleia Deniozou's PhD research. I understand that the information I provide by way of expert evaluation, including attitudes, opinions, recollections, and facts will be used only for the purposes of this research project. I also understand that my identity will be concealed in writing up the final thesis as well as any future publications and all information I provide will remain anonymous. Additionally, I am aware that this research may be published in the form of conference posters, papers, and journal papers, as well as in the form of a PhD thesis. I am finally aware that any data obtained as a consequence of my participation (i.e. recordings, transcripts, notes) will be kept safe and destroyed within 3 years of the research conclusion.

Name:

Signature:

Date:

If as a participant you have any questions regarding your involvement in this research, please do not hesitate to contact the principal researcher:

Thaleia Deniozou Principal researcher
Edinburgh College of Art, The University of Edinburgh
tdeniozou@gmail.com

Appendix B.3

User Evaluation Consent Form (Quantitative)

Research Overview

I am doing a PhD investigating the effectiveness of mobile games as learning tools for adult learners. In the context of the research I am looking to advance a set of design guidelines for the effective design and development of mobile game-based learning. I have developed the final version of a mobile iOS game prototype about vocabulary learning, which is designed to appeal to adult learners. Through this user evaluation study I am interested to investigate the effectiveness of the game and gather data on user experience, user engagement and user attitudes.

Nature of Involvement

I am interested in finding out about your experiences while playing the final version of the mobile iOS vocabulary learning game. I would like you to playtest the game and then complete a questionnaire in regards to your experience. While you play the screen of the mobile device will be recorded, to monitor your in-game interactions. It is anticipated that the evaluation session will last for approximately 30 minutes.

Confidentiality and Anonymity

For the requirements of the research, myself (Thaleia Deniozou - the principal researcher) will be present during the evaluation session. Tests will however be conducted in a confidential basis, as access to the research data will be restricted to myself, and my research supervisors. Although opinions and information shared during the session may be discussed in the final PhD thesis as well as later publications, identities will always be concealed and opinions will remain anonymous.

Consent Declaration

I have been provided with adequate information relating to the nature and objectives of this research project, and have been given the opportunity to ask questions about the research.

I agree to participate as a game tester for the mobile iOS vocabulary learning game, as part of Thaleia Deniozou's PhD research. I understand that the information I provide by way of user evaluation, including attitudes, opinions, recollections, and facts will be used only for the purposes of this research project. I also understand that my identity will be concealed in writing up the final thesis as well as any future publications and all information I provide will remain anonymous. Additionally, I am aware that this research may be published in the form of conference posters, papers, and journal papers, as well as in the form of a PhD thesis. I am finally aware that any data obtained as a consequence of my participation (i.e. recordings, transcripts, notes) will be kept safe and destroyed within 3 years of the research

conclusion.

Name:

Signature:

Date:

If you have any questions regarding your involvement in this research, please do not hesitate to contact the principal researcher:

Thaleia Deniozou Principal researcher
Edinburgh College of Art, The University of Edinburgh
tdeniozou@gmail.com

Appendix B.4

User Evaluation Consent Form (Qualitative)

Research Overview

I am doing a PhD investigating the effectiveness of mobile games as learning tools for adult learners. In the context of the research I am looking to advance a set of design guidelines for the effective design and development of mobile game-based learning. I have developed the final version of a mobile iOS game prototype about vocabulary learning, which is designed to appeal to adult learners. Through this user evaluation study I am interested to investigate the effectiveness of the game and gather data on user experience, user engagement and user attitudes.

Nature of Involvement

I am interested in finding out about your experiences while playing the final version of the mobile iOS vocabulary learning game. I would like you to playtest the game and then answer a number of questions in regards to your experience. Some of your activities may be audio and/or screen recorded and if so, this will become clear to you by the researcher. It is anticipated that the evaluation session will last for approximately 40-60 minutes.

Confidentiality and Anonymity

For the requirements of the research, myself (Thaleia Deniozou - the principal researcher) will be present during the evaluation session. Tests will however be conducted in a confidential basis, as access to the research data will be restricted to

myself, and my research supervisors. Although opinions and information shared during the session may be discussed in the final PhD thesis as well as later publications, identities will always be concealed and opinions will remain anonymous.

Consent Declaration

I have been provided with adequate information relating to the nature and objectives of this research project, and have been given the opportunity to ask questions about the research.

I agree to participate as a game tester for the mobile iOS vocabulary learning game, as part of Thaleia Deniozou's PhD research. I understand that the information I provide by way of user evaluation, including attitudes, opinions, recollections, and facts will be used only for the purposes of this research project. I also understand that my identity will be concealed in writing up the final thesis as well as any future publications and all information I provide will remain anonymous. Additionally, I am aware that this research may be published in the form of conference posters, papers, and journal papers, as well as in the form of a PhD thesis. I am finally aware that any data obtained as a consequence of my participation (i.e. recordings, transcripts, notes) will be kept safe and destroyed within 3 years of the research conclusion.

Name:

Signature:

Date:

If you have any questions regarding your involvement in this research, please do not hesitate to contact the principal researcher:

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Appendix C

List of Papers, Conferences and Lectures

Papers

Deniozou, T. 'mGBL in Architecture: Using Mobile Games to Support the Training of Architects in HE' in EAR Edinburgh Architecture Research, ESALA, University of Edinburgh (forthcoming 2016).

Deniozou, T. 'Mobile Games for Vocabulary Learning: Investigating m-GBL Opportunities for Adult Learners' in Papers in Education on-line publication, Moray House School of Education, University of Edinburgh (forthcoming 2016).

Conference Presentations

Deniozou, T. (2013). 'Investigating Mobile Game-Based Learning Opportunities for Adult Learners: a Case for Language Vocabulary'. Talk presented at the Interweaving: Connecting Educational Research Within, Across and Between Perspectives Conference, University of Edinburgh, 4 September 2013.

Deniozou, T. (2013). 'Creativity and Exploration in 3D Game Worlds'. Talk presented at the Life in 3D: Animation, Film and Sound Symposium, University of Edinburgh, 5 June 2013.

Deniozou, T. (2011). Employing Game Mechanics to Achieve Motivation and Engagement in Learning, Proceedings of the Annual Postgraduate Research Conference of Edinburgh College of Art, University of Edinburgh.

Guest Lectures

Deniozou, T. (2014, October 15). *Blender 3D in Higher Education Teaching: Modelling, Animation and Games*. Guest lecture conducted for the MSc Information Technology, School of Mathematical and Computer Sciences, Heriot-Watt University, Edinburgh.

Deniozou, T. (2013, November 21). *Elements of Game Design: Visual Style and Graphical Vocabularies*. Guest lecture conducted for the MA Digital Games: Theory & Design, Brunel University, London.

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